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DEWDROP-TRANQUILLE RIVER WILDLIFE HABITAT STUDY

Volume 2: Biophysical Inventory

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CHAPTER ONE
INTRODUCTION

In 1982, the Fish and Wildlife Branch, Thompson-Nicola Region 3, Ministry of Environment, entered into a joint management program with Balco Forest Industries and Ministry of Forests on the "Dewdrop-Tranquille River" mule deer winter range. Long-term logging plans and a cattle operation are also involved in this area. The Region requested the Terrestrial Studies Section of the Surveys and Resource Mapping Branch to undertake an ecological base inventory to permit logical planning and effective management. The study area is depicted in Figure 1.1.

The field work for this inventory took place in the summer of 1981. Snow depth and quality descriptions were made by the Surface Water Section of the Water Management Branch in the winter of 1981-82. Climate information was collected and interpreted by the Climatology Unit of the Air Studies and Program Management Section of the Waste Management Branch, and terrain, soils and vegetation information was collected, mapped and interpreted by the Terrestrial Studies Section. This base information has been evaulated towards habitat potential by an interdisciplinary team comprised of the disciplinary professionals and experts in wildlife management from the Regional office and the Surveys and Resource Mapping Branch.

The resulting products are: a vegetation landscape (ecological) map and its precursor soils and terrain maps, a data report, and a wildlife management interpretation report.

The Data Report is designed to present the factual base from which professional evaluations and judgements were made (to allow proper qualification and evaluation of those judgements) and to facilitate further interpretation for future integrated resource management of the winter range. The interpretations and evaluations for wildlife habitat management will be presented in the Wildlife Interpretation Report for Dewdrop Wildlife Habitat Management, to be published at a later date.

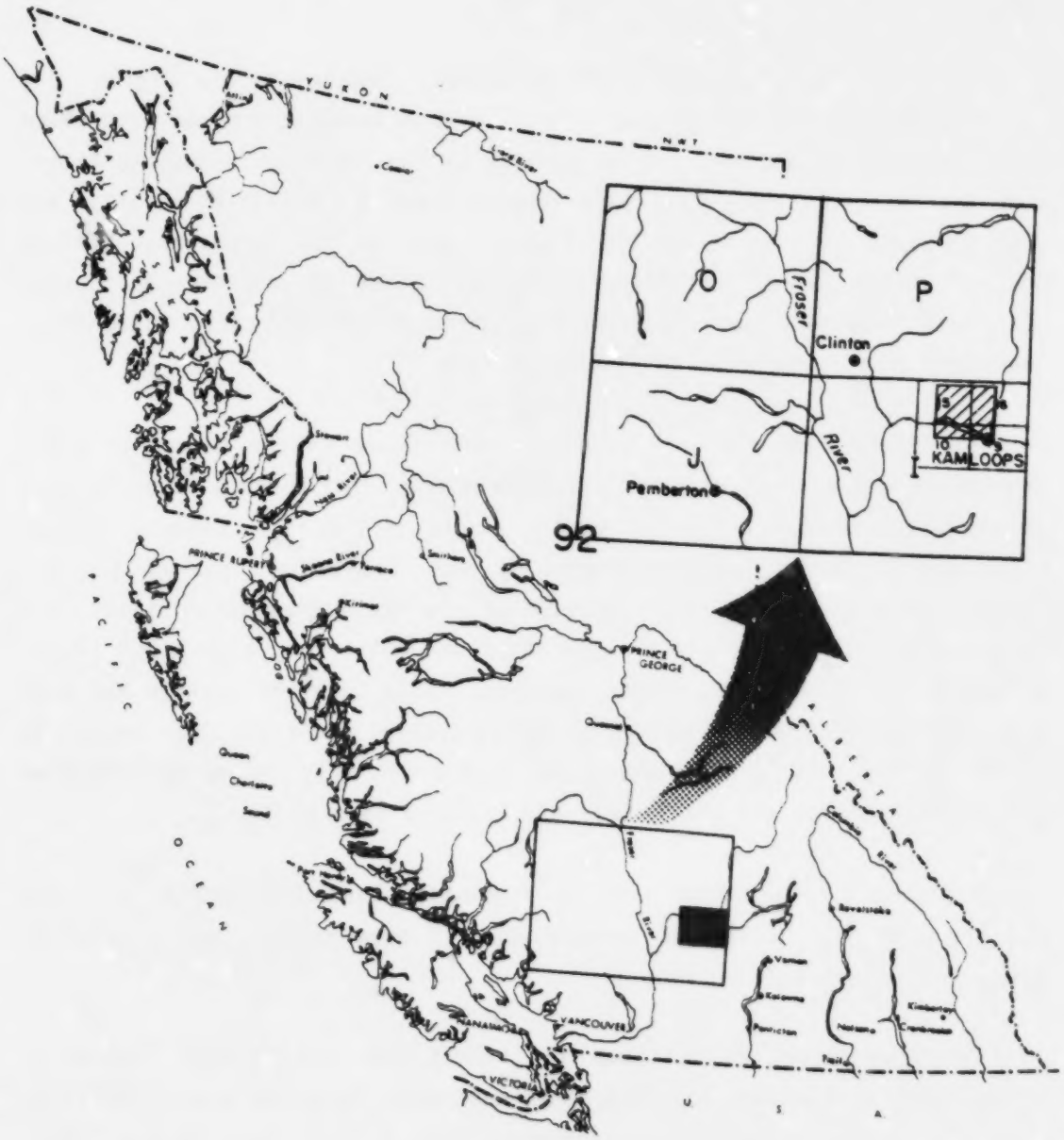


Figure 1.1 Location of Study Area.

CHAPTER TWO
CLIMATE

2.1 INTRODUCTION

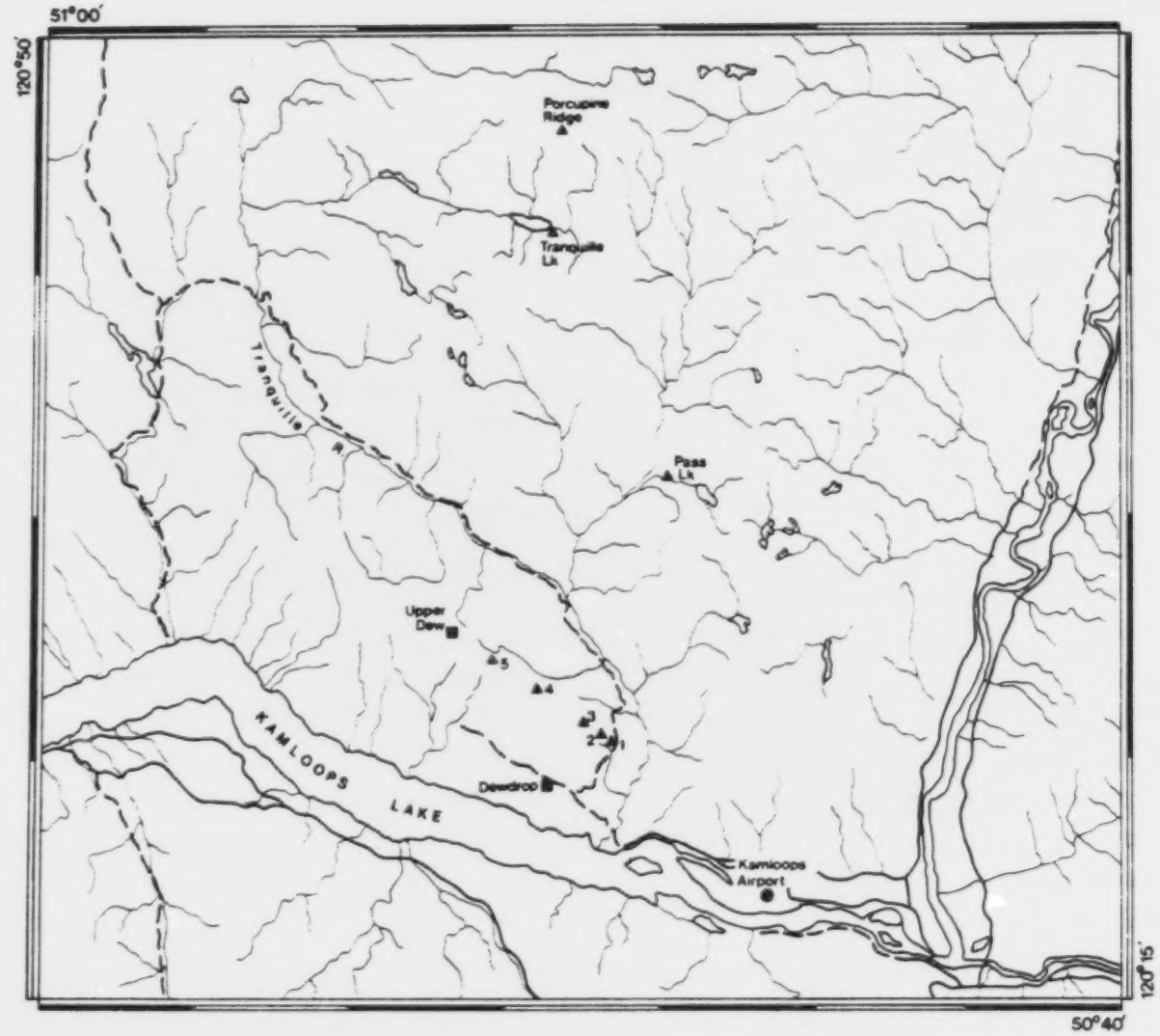
Climatic data are scarce within the Dewdrop/Tranquille River study area. Parameter maps of freeze free period, growing degree days (above 5°C), climatic moisture deficit and May to September precipitation are available for the region. These reconnaissance level maps were produced by the British Columbia Ministry of Environment using data collected from a network of climate stations operated during the period 1971 to 73. These data provide an overview of the summer climate of the area under investigation.

Snow, both depth and density, is likely the major climatic factor impeding the movement of wildlife in interior British Columbia. To further understand this problem a single season detailed investigation of the seasonal snow patterns within the Dewdrop/Tranquille River area was undertaken. In addition to snow information, temperature data were collected to delineate areas susceptible to cold air collection and examine the severity of winter minimum temperatures within the region.

The data which follows are, in general, derived from short-term stations and should be used with caution. In many cases the data have been extrapolated from nearby climate stations or have been derived using empirical models. The absolute value of the data presented may be questionable, however, the relative differences between sites are likely valid.

2.2 METHODS

Snow depth and water content data were gathered by Air Studies Branch (ASB) at 7 stations during the winter of 1981-82. In addition, data were collected at 3 long-term stations operated by Water Management Branch. The



SNOW SAMPLE SITES	ELEVATION (m)
▲ Pass Lake	870
▲ Tranquille Lake	1420
▲ Porcupine Ridge	1830
▲ 1	815
▲ 2	914
▲ 3	1082
▲ 4	1158
▲ 5	1212

TEMPERATURE & SNOW SAMPLE SITES	ELEVATION (m)
■ DEWDROP	613
■ UPPER DEW	1251
TEMPERATURE & PRECIPITATION SITE	
● KAMLOOPS AIRPORT	346

Figure 2.1 Climate Station Location Map.

10 stations, located within or adjacent to the Dewdrop/Tranquille River study area, were at elevations ranging from 613 to 1830 m and are shown in Figure 2.1. At each site snow depth and water content were measured at a minimum of 5 locations using a "Mt. Rose" snow sampling kit.

Temperature data were collected at 3 sites in or near the study area during the winter of 1981-82. The sites at 613 and 1251 m were installed and operated by ASB while the third site, Kamloops Airport (346 m), was maintained by Atmospheric Environment Service (AES). Data at the ASB stations were recorded by hygrothermographs with 31 day strip charts. These instruments were located in standard Stevenson screens with calibrated maximum and minimum thermometers. Electric clock failures were encountered at both stations during a cold spell in December. At the upper station snow packed the louvers of the Stevenson screen causing a loss of all of the data for March. Temperature data at Kamloops Airport were recorded manually on the hour using calibrated thermometers.

Soil temperature data were estimated using a model developed by Quellet (1973). This model requires estimates of the variation with elevation of monthly temperature, monthly precipitation and days with precipitation. Estimates of the long-term normals of these parameters for the months April to October were derived using data collected at ASB and AES stations in the Kamloops area. Winter data (November to February) were linearly interpolated from a limited data base made up of two stations, Kamloops Airport, at an elevation of 346 m, and Kamloops Mt. Lolo at 1737 m.

The variation with elevation of freeze free period and growing degree days above 5°C was derived from regression equations calculated by ASB. These equations, along with information on analysis techniques are presented in the working report "Kamloops Climatological Network Report" (in press).

Potential evapotranspiration (PET) was calculated using a modification of a model developed by Preistley and Taylor (1972). Hay (1979) lists estimates of solar radiation data for Summerland and these were used to

calculate the PET on various slope/aspect combinations. These PET data are likely conservative as we had no means of estimating the effects of slope and aspect on temperature.

2.3 INTERPRETATIONS

The data presented in Tables 2.1-2.4 are independent of topographic effects. The thermal data presented in Tables 2.1, 2.3 and 2.4 are based on limited information at well exposed sites and will be highly susceptible to changes in slope, aspect and location within the valley. Slope and aspect combinations will alter the solar radiation received at the surface and this will affect the surface temperature and resulting in steep south facing slopes being warmer than their north facing counterparts. At night, air near the surface is cooled as energy is lost to the atmosphere and the dense cool air moves down slope under the influence of gravity. Depressions, valley bottoms and other areas where air flow is impeded are susceptible to the collection of this cold air. The areas where the cold air pools will have lower minimum temperatures, shortened freeze free period, and reduced soil temperatures. Typically this occurs in such areas as the Tranquille River, Thompson River and Tranquille Lake. Topographic shading, another variable which is not considered in the data presentation, will also cause a reduction of solar energy received at the surface, and tend to reduce the daytime temperature, evapotranspiration and growing degree day accumulation. A typical example of this alteration to the microclimate occurs in the narrow valley of the Tranquille River. For a more complete description of the effects of topography on the freeze free period and growing degree days within the study area the reader is directed to the reconnaissance level climate parameter maps produced by the B.C. Ministry of Environment, Air Studies Branch.

Unlike temperature, which generally decreases with increasing elevation, precipitation increases as one proceeds from valley bottom to ridgetop (Table 2.2). Topography will likely affect the amount of precipitation

TABLE 2.1a ESTIMATED MONTHLY MEAN MAXIMUM TEMPERATURE (°C)

ELEV. (m)	ANNUAL	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
400	13.7	-3.3	2.2	9.1	15.9	21.1	25.0	28.5	27.2	21.0	12.9	4.7	0.0
600	12.4	-3.9	1.4	7.7	14.1	19.4	23.3	26.8	25.6	19.6	11.7	3.7	-0.9
800	11.1	-4.4	0.6	6.2	12.4	17.7	21.7	25.1	24.1	18.2	10.4	2.7	-1.8
1 000	9.8	-5.0	-0.3	4.8	10.6	16.0	20.1	23.5	22.5	16.7	9.2	1.7	-2.7
1 200	8.5	-5.5	-1.1	3.3	8.8	14.2	18.4	21.8	21.0	15.3	8.0	0.7	-3.5
1 400	7.1	-6.1	-1.9	1.8	7.0	12.5	16.8	20.2	19.4	13.9	6.8	0.3	-4.4
1 600	5.8	-6.6	-2.8	0.4	5.3	10.8	15.2	18.5	17.9	12.5	5.5	1.3	-5.3
1 800	4.5	-7.2	-3.6	-1.1	3.5	9.1	13.5	16.9	16.3	11.0	4.3	-2.4	-6.2

TABLE 2.1b ESTIMATED MONTHLY MEAN MINIMUM TEMPERATURE (°C)

ELEV. (m)	ANNUAL	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
400	3.0	-8.7	-5.1	-0.8	2.9	6.9	10.9	12.6	11.8	7.6	3.2	-1.2	-4.7
600	2.1	-9.2	-5.6	-1.7	1.9	5.9	9.9	11.7	11.0	6.9	2.4	-2.0	-5.5
800	1.3	-9.7	-6.0	-2.7	0.8	4.9	8.8	10.8	10.2	6.1	1.7	-2.8	-6.3
1 000	0.5	-10.1	-6.5	-3.6	-0.2	4.0	7.8	9.8	9.4	5.4	0.9	-3.6	-7.1
1 200	-0.3	-10.6	-6.9	-4.6	-1.2	3.0	6.8	8.9	8.6	4.7	0.2	-4.5	-7.9
1 400	-1.1	-11.0	-7.4	-5.5	-2.3	2.1	5.7	8.0	7.8	3.9	-0.6	-5.3	-8.7
1 600	-1.9	-11.5	-7.9	-6.5	-3.3	1.1	4.7	7.1	7.0	3.2	-1.3	-6.1	-9.5
1 800	-2.7	-11.9	-8.3	-7.4	-4.4	0.2	3.6	6.2	6.2	2.5	-2.1	-7.0	-10.3

TABLE 2.1c ESTIMATED MONTHLY MEAN TEMPERATURE (°C)

ELEV. (m)	ANNUAL	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
400	8.2	-6.0	-1.0	4.2	9.4	13.9	17.3	20.6	19.5	14.4	7.9	1.0	-2.5
600	7.1	-6.5	-1.8	3.0	8.0	12.7	16.6	19.3	18.3	13.2	7.0	0.2	-3.3
800	6.2	-7.1	-2.5	1.9	6.7	11.4	15.3	18.0	17.1	12.1	6.1	-0.5	-4.0
1 000	5.2	-7.6	-3.3	0.7	5.4	10.2	14.0	16.8	16.0	10.9	5.1	-1.3	-4.8
1 200	4.2	-8.1	-4.0	-0.5	4.1	9.0	12.7	15.5	14.8	9.8	4.2	-2.0	-5.6
1 400	3.1	-8.7	-4.8	-1.6	2.7	7.8	11.4	14.3	13.6	8.6	3.2	-2.7	-6.4
1 600	2.1	-9.2	-5.5	-2.8	1.4	6.6	10.1	13.0	12.4	7.4	2.3	-3.5	-7.2
1 800	1.1	-9.3	-6.3	-3.9	0.1	5.4	8.7	11.7	11.2	6.3	1.4	-4.2	-8.0

TABLE 2.2 ESTIMATED MONTHLY PRECIPITATION (mm)

ELEV. (m)	MAY	JUNE	JULY	AUG.	SEPT.	SEASONAL
400	18.1	33.4	24.2	25.4	19.2	120.2
600	22.0	37.2	27.9	31.0	23.3	141.4
800	26.0	40.7	31.6	36.8	27.5	162.6
1 000	30.0	44.2	35.4	42.5	31.8	183.8
1 200	34.0	47.5	39.1	48.4	36.0	205.0
1 400	38.1	50.6	42.7	54.3	40.4	226.2
1 600	42.2	53.8	46.4	60.2	44.7	247.4
1 800	46.4	56.9	50.1	66.1	49.1	268.6

TABLE 2.3 GROWING DEGREE DAYS (> 5°C)
AND FREEZE-FREE PERIOD (DAYS)

ELEV. (m)	GDD> 5°C	FFP (days)
400	1949	142
600	1735	129
800	1522	116
1 000	1309	103
1 200	1096	90
1 400	882	77
1 600	669	64
1 800	456	51

TABLE 2.4
ESTIMATED MONTHLY MEAN SOIL TEMPERATURES (°C) AT A SOIL DEPTH OF 50 cm

Elev. (m)	ANNUAL	JUNE TO SEPT	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
400	10.4 mild	19.4	1.0	0.7	2.3	8.8	13.4	17.6	21.3	21.4	17.4	11.4	6.7	3.3
600	9.2 mild	17.6	0.7	0.2	1.5	6.6	12.0	16.2	19.2	19.1	15.8	10.1	5.8	2.7
800	8.0 mild	15.9	0.4	-0.2	0.8	4.7	10.6	14.9	17.3	17.2	14.2	8.8	5.0	2.3
1000	6.9 cool	14.2	0.2	-0.4	0.4	3.3	8.8	13.3	15.4	15.5	12.6	7.6	4.3	2.0
1200	5.7	12.4	-0.1	-0.8	-0.1	2.2	6.7	11.3	13.5	13.9	11.0	6.3	3.5	1.4
1400	4.7	11.0	-0.3	-1.2	-0.6	1.2	5.1	9.7	12.1	12.7	9.5	5.0	2.8	0.6
1600	3.9	9.8	-0.6	-1.3	-0.9	0.7	3.4	7.9	10.7	11.7	8.8	3.9	2.2	0.7
1800	3.4	9.0	-0.7	-1.6	-1.1	0.3	2.3	6.5	9.9	11.3	8.1	3.7	1.5	0.4

received at the surface, this is especially true in the vicinity of larger physical features. Such obstructions may increase precipitation on the windward side and decrease it on the leeward. In addition, certain valleys may act as funnels and have abnormally high precipitation because of their orientation into the prevailing wind. The Watching Creek area below Pass Lake is believed to fall into this category. Annual precipitation data for the study area are sparse with only two long-term stations, Kamloops Airport (346 m) and Mt. Lolo (1737 m) located in the immediate vicinity. At Kamloops Airport 36% of the annual 256.5 mm of precipitation occurs as snow, while at Mt. Lolo 48% of the annual 514.1 mm is in the form of snow (Atmospheric Environment Service, 1981). The precipitation data for Mt. Lolo are suspect, due to the extremely windy and exposed location, and are likely too low to be representative of an elevation of 1737 m (R.D. Marsh, personal communication[1]).

Tables 2.5a to 2.5h show the effect of elevation, slope and aspect on the potential evapotranspiration (PET) and climatic moisture balance (CMB). PET is defined as the amount of moisture which would be removed from the soil, if available, by transpiration from vegetation and evaporation from the surface. CMB is defined as the difference between precipitation (PPT) and PET. The PET value is dependant upon the incoming solar radiation received at the surface and shows a high variability with time of year, slope and aspect. In addition, PET is reduced as temperatures decrease with increasing elevation.

CMB shows the relationship between the thermal and moisture regimes. Negative values of CMB indicate a deficit in the climatic moisture budget while positive values indicate a surplus. In the Dewdrop/Tranquille River study area climatic moisture deficits are more prevalent than surpluses. Seasonal surpluses occur only on the steepest north facing slopes at elevations above 600 m and range from +17 to +158 mm. With the exception of the steepest north face above 1400 m all slope/aspect combinations have a deficit condition for part or all of the May to September season with the

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[1] R.D. Marsh, Climatologist, Waste Management Branch, B.C. Ministry of Environment, Victoria, B.C.

TABLE 2.5a

Estimated Average Seasonal Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal at an Elevation of 400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	120	120	120	120	120	120
	PET	576	518	440	347	253	157
	CMB	-456	-398	-320	-227	-133	-37
SOUTH	PPT	120	120	120	120	120	120
	PET	576	617	635	634	613	570
	CMB	-456	-497	-515	-514	-493	-450
NE/NW	PPT	120	120	120	120	120	120
	PET	576	542	487	417	345	274
	CMB	-456	-422	-367	-297	-225	-154
SE/SW	PPT	120	120	120	120	120	120
	PET	576	609	626	628	609	573
	CMB	-456	-489	-506	-508	-489	-453
E/W	PPT	120	120	120	120	120	120
	PET	576	580	568	545	512	471
	CMB	-456	-460	-448	-425	-392	-351

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE 2.5b

Estimated Average Seasonal Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal at an Elevation of 600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	141	141	141	141	141	141
	PET	561	503	427	337	246	151
	CMB	-420	-362	-286	-196	-105	-10
SOUTH	PPT	141	141	141	141	141	141
	PET	561	600	618	617	597	554
	CMB	-420	-459	-477	-476	-456	-413
NE/NW	PPT	141	141	141	141	141	141
	PET	561	527	474	406	335	292
	CMB	-420	-386	-333	-265	-194	-151
SE/SW	PPT	141	141	141	141	141	141
	PET	561	594	610	611	593	558
	CMB	-420	-453	-469	-470	-452	-417
E/W	PPT	141	141	141	141	141	141
	PET	561	564	553	530	498	458
	CMB	-420	-423	-412	-389	-357	-317

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE 2.5c

Estimated Average Seasonal Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal at an Elevation of 800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	163	163	163	163	163	163
	PET	543	486	412	324	236	144
	CMB	-380	-323	-249	-161	-73	+19
SOUTH	PPT	163	163	163	163	163	163
	PET	543	581	599	598	578	536
	CMB	-380	-418	-436	-435	-415	-373
NE/NW	PPT	163	163	163	163	163	163
	PET	543	510	457	392	323	255
	CMB	-380	-347	-294	-229	-160	-92
SE/SW	PPT	163	163	163	163	163	163
	PET	543	575	591	592	573	540
	CMB	-380	-412	-428	-429	-410	-377
E/W	PPT	163	163	163	163	163	163
	PET	543	546	535	513	481	442
	CMB	-380	-383	-372	-350	-318	-279

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE 2.5d

Estimated Average Seasonal Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal at an Elevation of 1000 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	184	184	184	184	184	184
	PET	525	471	399	312	227	138
	CMB	-341	-287	-215	-128	-43	+46
SOUTH	PPT	184	184	184	184	184	184
	PET	525	563	580	579	559	518
	CMB	-341	-379	-396	-395	-375	-334
NE/NW	PPT	184	184	184	184	184	184
	PET	525	493	443	378	311	245
	CMB	-341	-309	-259	-194	-127	-61
SE/SW	PPT	184	184	184	184	184	184
	PET	525	557	572	573	555	522
	CMB	-341	-373	-388	-389	-371	-338
E/W	PPT	184	184	184	184	184	184
	PET	525	528	518	497	465	427
	CMB	-341	-344	-334	-313	-281	-243

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE 2.5e

Estimated Average Seasonal Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal at an Elevation of 1200 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	205	205	205	205	205	205
	PET	507	453	384	300	219	131
	CMB	-302	-248	-179	-95	-14	+74
SOUTH	PPT	205	205	205	205	205	205
	PET	507	543	560	559	540	501
	CMB	-302	-338	-355	-354	-335	-296
NE/NW	PPT	205	205	205	205	205	205
	PET	507	476	427	364	298	234
	CMB	-302	-271	-222	-159	-93	-29
SE/SW	PPT	205	205	205	205	205	205
	PET	507	538	553	554	536	504
	CMB	-302	-333	-348	-349	-331	-299
E/W	PPT	205	205	205	205	205	205
	PET	507	510	500	479	449	412
	CMB	-302	-305	-295	-274	-244	-207

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE 2.5f

Estimated Average Seasonal Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal at an Elevation of 1400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	226	226	226	226	226	226
	PET	489	437	370	288	209	124
	CMB	-263	-211	-144	-62	+17	+102
SOUTH	PPT	226	226	226	226	226	226
	PET	489	525	541	540	521	483
	CMB	-263	-299	-315	-314	-295	-257
NE/NW	PPT	226	226	226	226	226	226
	PET	489	459	411	351	287	224
	CMB	-263	-233	-185	-125	-61	+2
SE/SW	PPT	226	226	226	226	226	226
	PET	489	519	534	534	518	486
	CMB	-263	-293	-308	-308	-292	-260
E/W	PPT	226	226	226	226	226	226
	PET	489	492	482	462	432	397
	CMB	-263	-266	-256	-236	-206	-171

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE 2.5g

Estimated Average Seasonal Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal at an Elevation of 1600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	247	247	247	247	247	247
	PET	471	420	355	275	199	117
	CMB	-224	-173	-108	-28	+48	+130
SOUTH	PPT	247	247	247	247	247	247
	PET	471	505	521	519	501	464
	CMB	-224	-258	-274	-272	-254	-217
NE/NW	PPT	247	247	247	247	247	247
	PET	471	441	395	336	274	214
	CMB	-224	-194	-148	-89	-27	33
SE/SW	PPT	247	247	247	247	247	247
	PET	471	499	514	515	498	468
	CMB	-224	-252	-267	-268	-251	-221
E/W	PPT	247	247	247	247	247	247
	PET	471	473	464	444	416	381
	CMB	-224	-226	-217	-197	-169	-134

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE 2.5h

Estimated Average Seasonal Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal at an Elevation of 1800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	269	269	269	269	269	269
	PET	452	403	340	263	190	111
	CMB	-183	-134	-71	+6	+79	+158
SOUTH	PPT	269	269	269	269	269	269
	PET	452	485	501	499	482	446
	CMB	-183	-216	-232	-230	-213	-177
NE/NW	PPT	269	269	269	269	269	269
	PET	452	423	379	322	262	203
	CMB	-183	-154	-110	-53	+7	+66
SE/SW	PPT	269	269	269	269	269	269
	PET	452	480	493	495	479	448
	CMB	-183	-211	-224	-226	-210	-179
E/W	PPT	269	269	269	269	269	269
	PET	452	455	445	421	399	365
	CMB	-183	-186	-176	-152	-130	-96

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

largest seasonal deficit of 515 mm occurring on a south face at 400 m. The reader must be aware that these CMB data are derived exclusively from climatic parameters. Soil moisture from snowmelt, subsurface water and the effects of various soil textures on the available water storage capacity have not been considered. The CMB can be used as a guideline to estimate the intensity and duration of periods of drought at various elevation, slope and aspect combinations.

Figures 2.2a, 2.2b and 2.2c show the variation in temperature at 3 climatological stations operating during the 1981-82 winter at elevations of 346 to 1251 m. The lower two stations (Kamloops Airport and Dewdrop) are located in valley bottom areas which were subject to cold air collection and as a result they show a larger range in temperature than the well drained Upper Dew site at 1251 m. At the upper site the maximum temperature was generally cooler but the minimum temperatures tended to be warmer. Figures 2.3a, 2.3b and 2.3c show the difference in minimum temperature between the three sites. Since data at the upper site are missing after February 24, 1982 a common data base of December 1, 1981 to February 24, 1982 was chosen for comparison purposes. Figure 2.3a shows that 21% of the time the minimum temperature at Dewdrop was warmer, by as much as 5°C, than Kamloops Airport. Figure 2.3b demonstrates that the inversion is more intense (11°C) and more frequent (33%) when Upper Dew is compared to Kamloops Airport. A comparison of the two upper stations (Fig. 2.3c) indicates that the minimum temperature was warmer at Upper Dew than at Dewdrop 56% of the time. As mentioned previously, cold air collection in the lower valleys likely causes these inversion conditions. In addition, during periods of cold Arctic outbreaks the cold air recedes from the valley at a much slower rate than it does from the ridge top areas. As a result the ridge top may be in a relatively warm air mass while the lower valleys are in much colder air which is slowly being modified from above. Under these conditions not only is the temperature regime different but the relative humidity of the air and the cloud cover may be greater on the lower slopes than that observed at the upper sites.

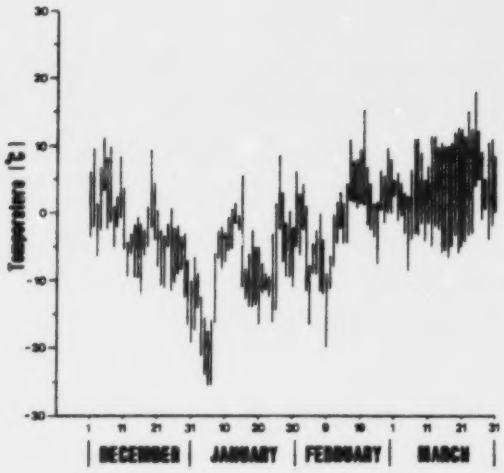

FIGURE 2.2a Maximum and Minimum Temperature (°C) at Kamloops Airport During the Winter 1981-82

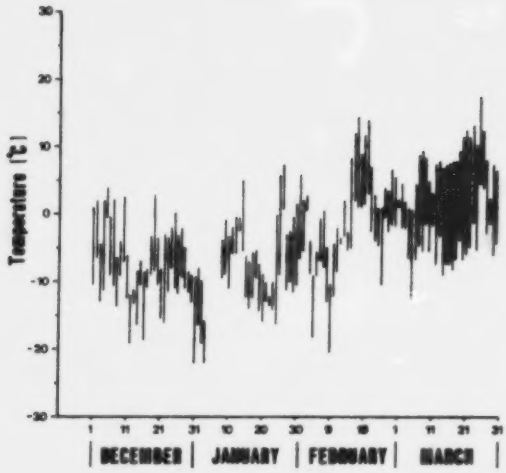

FIGURE 2.2b Maximum and Minimum Temperature (°C) at Dewdrop During the Winter 1981-82

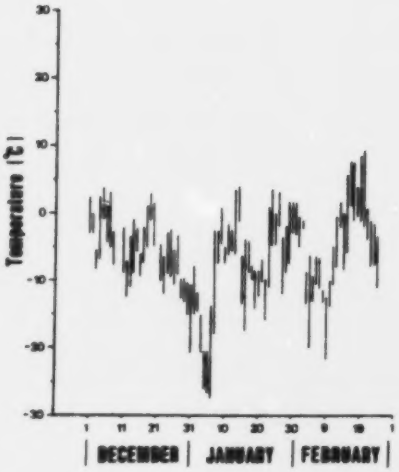

FIGURE 2.2c Maximum and Minimum Temperature (°C) at Upper Dew During the Winter 1981-82

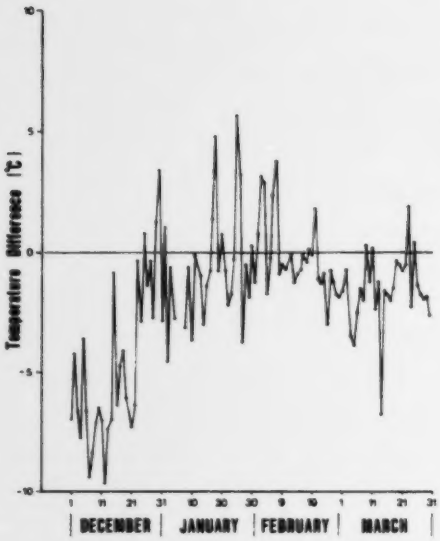

FIGURE 2.3a Difference in Daily Minimum Temperature (°C) Between Dewdrop and Kamloops Airport During the Winter 1981-82

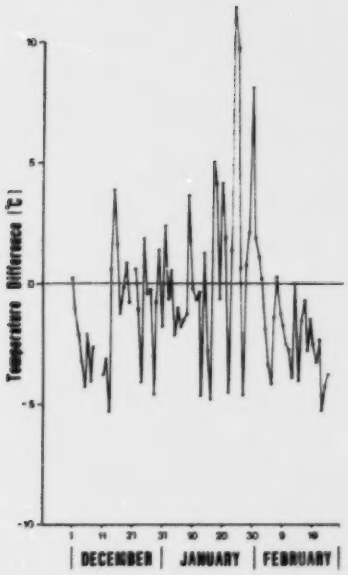

FIGURE 2.3b Difference in Daily Minimum Temperature (°C) Between Upper Dew and Kamloops Airport During the Winter 1981-82

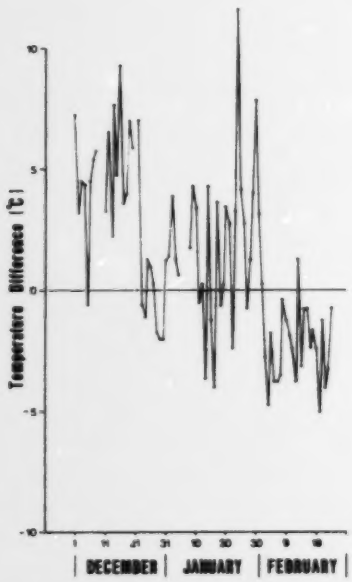

FIGURE 2.3c Difference in Daily Minimum Temperature (°C) Between Upper Dew and Dewdrop During the Winter 1981-82

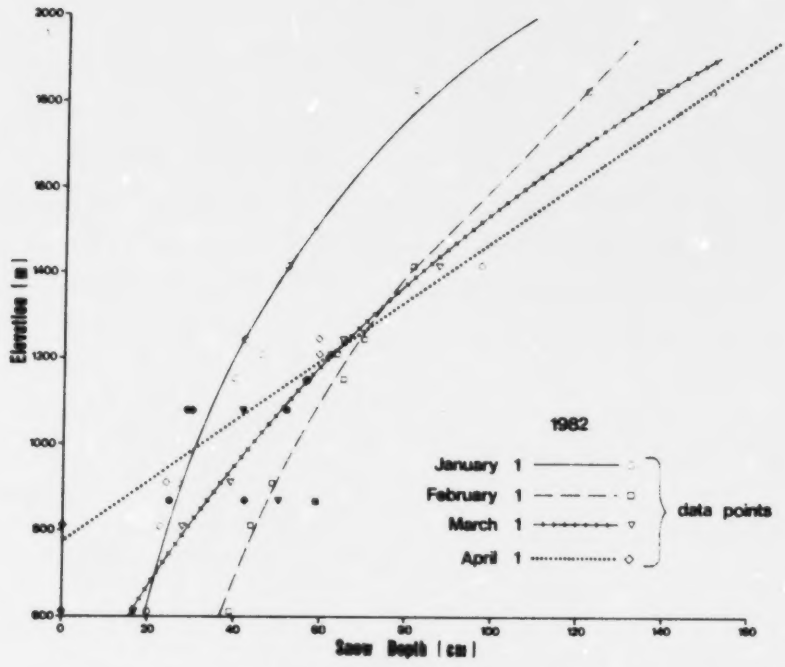

FIGURE 2.4 1982 Monthly Snow Depth (cm) versus Elevation (mm) (Solid Data Points were not used in the regression equations)

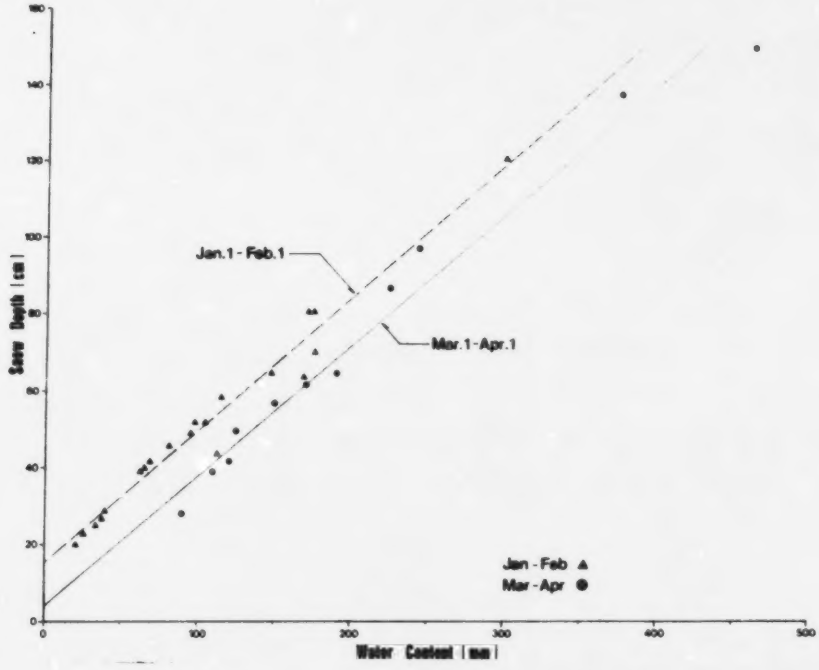

FIGURE 2.5 1982 Snowdepth (cm) versus Water Content (mm)

Also, during 1981 portions of the site were logged, altering the site characteristics. For these reasons the Pass Lake data were not used in the regression equations presented in Fig. 2.4 and the data from this station are shaded.

A second data point, shaded in Fig. 2.4, was not used in the regression equations due to site location. This site, at an elevation of 1082 m, was situated on a partially exposed south face and as a result of this exposure the snowdepth was substantially lower than more modestly situated sites at a similar elevation. The snowdepth was lower by 12% (February 1), 32% (April 1) and averaged 20% during the spring of 1982. It is likely that decreases in snowdepth of this magnitude would not be uncommon on south facing slopes, a result of snow melt and sublimation losses. Finally, Fig. 2.4 shows that site exposure had a slight effect on the snowdepth data collected at 1251 m. The data at this site were, in general, slightly less than those collected at an elevation of 1212 m. In this case the decrease in snowdepth is believed to be due to the slightly windblown exposure at the upper site. Such situations are common on exposed ridges and knolls throughout the study area.

2.4 DATA

The data presented in this section have all been extrapolated from a limited data base using methods outlined in Section 2.2. Seasonal CMB data are presented in Tables 2.5a to 2.5h. Additional monthly data are given in Appendix A.

TABLE 2.6

Comparison of Average Snowpack and Standard Deviation (S.D.) vs. 1982 Snowpack

STATION	PARAMETER	PERIOD	FEB. 1	MARCH 1	APRIL 1
Porcupine Ridge (1830 m)	Snowdepth (cm)	Average	122	126	146
		S.D.	16	23	28
		1982	121	139	150
	Water Content (mm)	Average	342	353	442
		S.D.	77	79	121
		1982	300	376	462
Tranquille Lake (1420 m)	Snowdepth (cm)	Average	74	80	86
		S.D.	10	15	18
		1982	81	87	97
	Water Content (mm)	Average	179	206	245
		S.D.	40	51	66
		1982	173	224	243
Pass Lake (870 m)	Snowdepth (cm)	Average	45	39	22
		S.D.	13	18	19
		1982	59	50	43
	Water Content (mm)	Average	93	104	73
		S.D.	30	45	63
		1982	115	125	121

The maximum snowdepth below 1400 m was observed during the February 1st snow sample. Above 1400 m the maximum snowdepth was measured with the April 1st sample. Maximum snow water content was observed March 1st below 1400 m and April 1st at the higher elevations. Both the snowdepth and water content maximums agree well with the long-term averages (B.C. Ministry of Environment, 1980).

The snowdepth vs. water content data (Fig. 2.5) were grouped into two data sets dependent upon time of snowfall. This was necessary because the snowpack early in the spring was light and powdery while in the latter two months it was more compressed. Grouping the data in this manner yielded correlation coefficients in excess of 0.98 with a standard error of less than 6 cm snowdepth.

As a test of the relevance of the 1982 snowpack data they were compared against the long-term averages (Table 2.6). The snowdepth and water content at the two high elevation stations were very close to the long-term averages. At the Pass Lake station the February 1 and April 1 snowdepth data exceeded the long-term average by more than one standard deviation. Further analysis of the data indicated that Pass Lake had an abnormally large year to year variation. The standard deviation of the long-term snowdepth data at the Porcupine Ridge and Tranquille Lake stations indicates that approximately two thirds of the data are within 20% of the long-term average value. The 1982 data at these two sites were well within this range with a measured maximum deviation from the long-term average of +13%. At Pass Lake, however, the standard deviation of the long-term average snowdepth is much larger ranging from 29% in February to 86% in April. The 1982 data for February and April showed an even greater variation, +31% and +95% respectively. These data are believed to be abnormally high for stations at an elevation of 870 m in the study area due to site location and recent site modification. The site is located in the lower region of Watching Creek, an increased precipitation area, as mentioned earlier.

CHAPTER THREE
SOIL AND TERRAIN

3.1 INTRODUCTION

Soil and terrain (surficial material) conditions for the study area are described in this chapter. The descriptions are intended to be used with the 1:50 000 scale soil and terrain maps.

Soil is an important resource for several reasons. All land based renewable resources are in some way dependent upon soil, which is basically a non-renewable resource due to the very slow rate at which it develops. This fact necessitates conservation of this basic resource in order to maintain optimum yields of timber, wildlife, water, recreation, forage and agricultural crops. Soils are also useful for predicting the natural productivity of these renewable resources, and their reponse to management.

Soil refers to the material immediately below the earth's surface which directly influences the kinds of plants that grow on a site and the rate at which these plants grow. Thus, the identification of relatively homogeneous kinds of soils provides a framework for the identification of vegetation and ecosystem types, habitats for wildlife, and for assessing the growth characteristics (productivity) of commercial forests and rangelands.

The general engineering properties of representative soils are also described in this chapter. Samples were taken from the relatively unweathered parent (surficial) material to determine these general properties. The Unified soil group as defined by the Asphalt Institute (1969), is given for the major materials of the area in Section 3.7.1. The Unified soil group provides inferences on soil erodibility, subgrade characteristics and shear strength.

The soil and terrain inventory was by design a survey of intermediate intensity (Survey Intensity Level 3 according to Agriculture Canada, 1981). The map unit delineations typically vary in size from 10 to 100 ha (25 to 250 acres).

3.2 SURVEY PROCEDURES

Prior to field work, aerial photographs were analysed to delineate different landforms, slopes, aspects, and vegetation conditions. Recent (1976) aerial photography at an approximate scale of 1:40 000 was used. A preliminary soil legend was prepared on the basis of Young's (1976) reconnaissance soil map. This 1:100 000 map representing a Level 4 survey was a valuable aid in the initial interpretation of aerial photographs.

Field survey by foot, vehicle, and helicopter in 1981 provided checking of airphoto interpretation. Soil and site (landscape) conditions were examined and described according to procedures outlined in Describing Ecosystems in the Field (Walmsley et al, 1980). Soils were classified at the soil family level using The Canadian System of Soil Classification (Canada Soil Survey Committee, 1978). Representative soils were sampled for physical and chemical analyses in the laboratory.

Soil and ecosystem features were inspected and described on 75 sites, for an average inspection density of one field check per 4 km^2. Approximately half of the map delineations were traversed by foot or vehicle. The remaining map delineations were viewed from a helicopter to assist in photo interpretation. A map showing the location of ground inspections is available, as are the completed site and soil field description forms.

Following field work, the soil legend, and soil and terrain mapping were finalized on the aerial photographs. Map unit boundaries were transferred onto a 1:50 000 topographic base map.

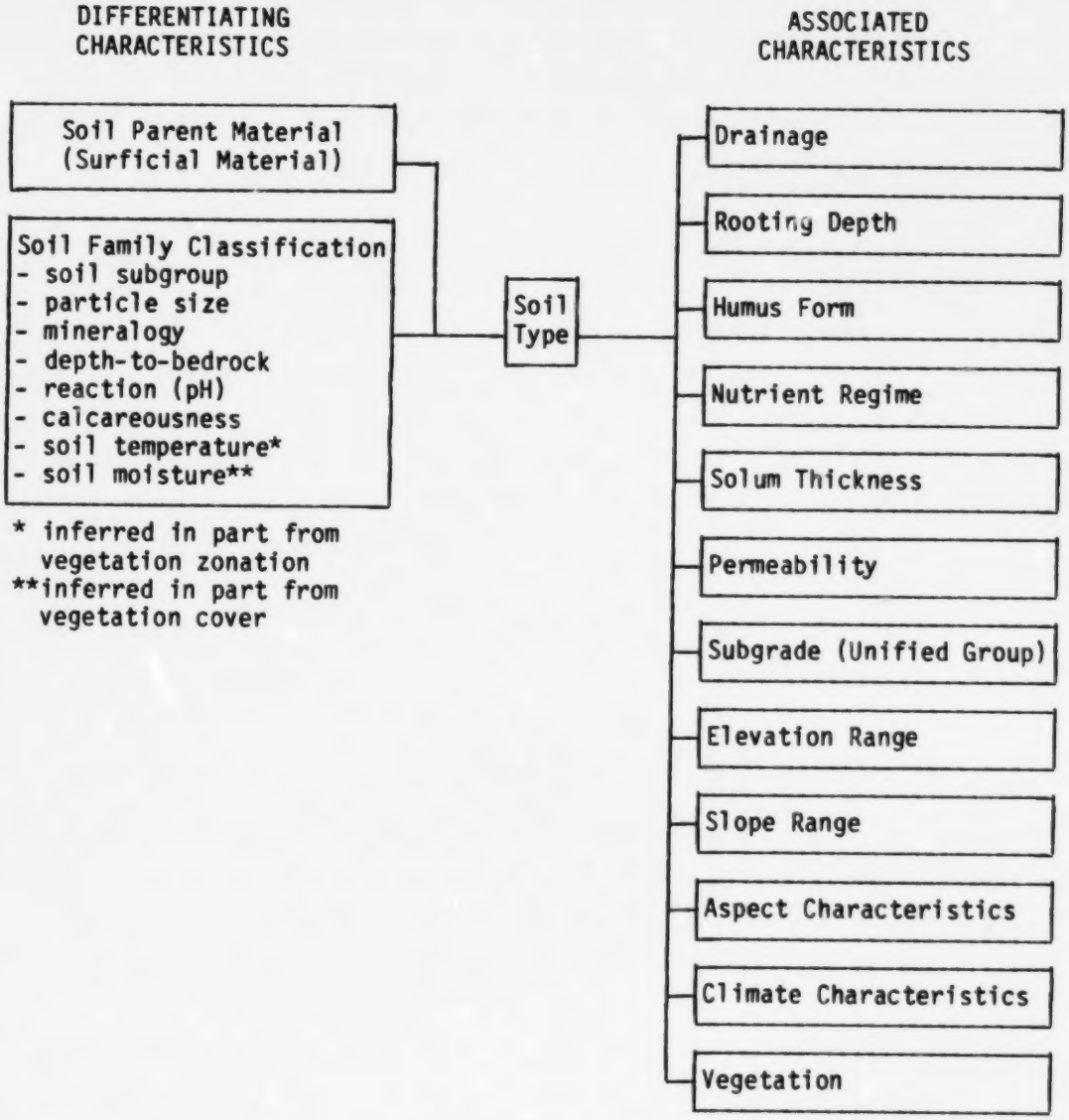

FIGURE 3.1

SCHEME FOR IDENTIFYING AND DESCRIBING SOIL TYPES

Terrain in the study area was differentiated by genetic materials, surface expression, and modifying processes (such as gullying) according to the Terrain Classification System (Resource Analysis Branch, 1976). The major surficial (genetic) materials differentiated were: morainal (till), colluvial, fluvial, lacustrine, and organic deposits.

Soils were first differentiated by these major surficial materials, and then by differences in dominant soil family characteristics. The soil family is a taxonomic category which includes a description of soil subgroup, particle-size class, mineralogy, depth-to-bedrock, reaction (pH) and calcareousness class, and soil climate including soil temperature class and soil moisture subclass. The soil family was used to help finalize the soil legend and in the description of soil types (see Figure 3.1). Organic soils were recognized but not classified due to the variability encountered.

Soil and terrain map unit symbols employed in the survey are described directly on each map legend.

3.3 SURFICIAL DEPOSITS (SOIL PARENT MATERIALS)

The soils of the area have developed on several types of materials; these parent (surficial) materials and their general characteristics are discussed below. Additional information is given for each soil type in section 3.6 and on the legends which accompany the terrain and soil maps.

Morainal (till) materials were deposited directly by glaciers. These deposits are the most widespread in the study area, especially on moderate slopes between 5 and 45%.

Till material was deposited in the area primarily as a blanket (thicker than 1 m over bedrock) whose topography is controlled by the underlying

bedrock. On the high plateau south of Tranquille Lake, distinct drumlinoid landforms are predominant. The drumlins appear to be bedrock controlled, as some inspections revealed a veneer of till (less than 1 m) over bedrock.

The till materials in the area are primarily medium-textured, with loam to sandy clay loam being dominant. A few areas have sandy loam and clay loam textures. Coarse fragment content varies from 15 to 50%, with most deposits containing between 30 and 40% coarse fragments. The dominant soil family particle-size class is loamy-skeletal, although some deposits are in the fine-loamy class. The Unified soil group is primarily SC indicating a mixture of sand and clay material.

Most soils developed on till are well to moderately well drained. In the subalpine zone, in receiving and depressional landscape positions, seepage sometimes results in imperfect to poor drainage. These localized conditions exist in the high plateau south of Tranquille Lake between the till drumlins.

Soils developed on till materials tend to have a mesic ecological moisture regime. Mesic sites are those whose moisture regime primarily reflects climatic conditions and is not overly influenced by edaphic conditions such as rapid or poor drainage. Mesic sites tend to consist of deep medium-textured, moderately well to well drained soils on moderate slopes. All of these conditions, as mentioned, generally exist for the area's till-derived soils.

Colluvial materials are products of mass wastage that have reached their present position by gravity-induced downslope movement. Colluvium is the second most dominant material (after morainal deposits) in the study area, and are most common on slopes exceeding 45%.

Colluvium occurs either as a veneer (depth-to-bedrock less than 1 m) or as a blanket (depth-to-bedrock greater than 1 m). Above the lower elevation

grasslands, colluvial veneers often support open forests with many exposed bedrock outcrops, while the blankets usually support more stable, densely-forested slopes. A few colluvial aprons (talus slopes) occur in the area below bedrock outcrops; these deposits often consist of exposed (sparsely vegetated) rubbly or blocky material.

Colluvial soils are medium-to-coarse-textured; the fine fraction (less than 2 mm diam.) is dominantly loam or sandy loam. Coarse fragment content varies from 30 to 70% (mainly 40 to 60%). Soil family particle-size class is dominantly loamy-skeletal; a few sites were sandy-skeletal. The Unified soil group is usually either GM or SM indicating high gravel content and a mixture of sand and silt material. The material, however, is often very shallow to bedrock.

Soil drainage varies from rapid to well due to the porous, coarse-textured nature of colluvium, and its usual occurrence in shedding slope positions. The ecological moisture regime varies from xeric on steep, shallow-to-bedrock areas to mesic in areas where colluvium is deeper.

Fluvial materials are deposits which have been transported and deposited by streams and rivers; they may or may not be subject to flooding.

Active fluvial materials are those on floodplains which are subject to periodic flooding and have riparian vegetation. Soils developed on materials of this origin are limited in the study area and are confined to areas along the Tranquille River and the floors of numerous gulleys harboring small tributary drainage channels. Most of these soil areas are too small to be mapped at a scale of 1:50 000, and thus are shown as a minor part of a larger map unit. These soils are often imperfectly to moderately well drained with some seasonally high water tables. Ecological moisture regime is often hygric to subhygric in sharp contrast to the drier adjacent uplands.

Inactive fluvial materials are more widely distributed in the study area. They occur as terraces above present-day floodplains, steep terrace

escarpments, fans, and blankets of material overlying mainly till material at depth. These soils tend to be well to rapidly drained with mesic to submesic moisture regimes.

Fluvial deposits in general are coarse-textured and loose, with sandy loam to sand textures. Coarse fragment content varies widely, from 0 to 70%, but mainly ranges between 50 and 70%. Soil family particle-size class is generally sandy-skeletal. The Unified soil group is often GP indicating poorly graded (well-sorted) gravel and sand material, and, less commonly, SP where fewer gravels are present.

Lacustrine materials are sediments that have settled from suspension in lakes. These materials occur in only a few isolated areas, mainly at the lowest elevations in the vicinity of Kamloops Lake. Textures are generally silt or silt loam with few or no coarse fragments. The Unified soil group is MH or ML. Soils developed on lacustrine are usually well drained.

Organic deposits are scattered throughout the higher plateaus of the study area in depressional landscape positions. The depressional areas receive and accumulate seepage from upslope soils and are generally saturated with water throughout the growing season. The soils are thus very poorly drained and the ecological moisture regime is generally subhydric or hydric. The Unified soil group is Pt for peaty.

Eolian deposits, which have been transported by winds, often occur as a thin capping over the other materials in the lower grasslands, where bluebunch wheat grass is common. These areas have very little protective litter (duff) material, with mainly exposed bare mineral soil, which can be readily removed and redistributed by strong winds. These deposits are silty to sandy in texture. Eolian material is generally thinner in the forested soils.

Volcanic ash deposits were found in the Tranquille valley buried by colluvial deposits and in one wet mineral (Gleysolic) soil on the high

plateau south of Tranquille Lake. The presence* of these deposits here suggests that some ash probably has been mixed in the surface of most of the more stable soils in the area. The ash deposits are silty in texture. Fulton (1975) noted that ash in nearby areas are from either the eruption of Mount Mazama about 6600 years ago, or an eruption of Mount St. Helens which occurred about 3200 years ago.

Bedrock outcrops are common in parts of the study area, particularly on the steep, south facing slopes north of Kamloops Lake. Materials less than 10 cm thick over bedrock are considered and mapped as bedrock.

3.4 SOIL CLASSIFICATION

Seven soil orders were found to occur in the area:

Chernozemic soils occur in the grasslands where a relatively thick (>10 cm) organic matter enriched surface horizon (Ah) exists. Because of high summer temperatures and high evapotranspiration rates, coupled with low amounts of precipitation, tree growth is inhibited and soil leaching is limited. This leads to the accumulation of the decomposition products of grasses, particularly their roots, in the topsoil, resulting in Ah horizon.

At the lower elevations of the Interior bunch grass zone, where soil temperatures are highest, and precipitation is lowest, grass production is reduced resulting in low levels of organic matter in the topsoil. This results in brown coloured Ah horizons when dry. These soils are Orthic Browns as they also have a B horizon below the Ah.

In mid-to-high elevations of the Interior bunch grass zone, slightly cooler temperatures coupled with slight increases in precipitation results in slightly higher levels of organic matter in the Ah horizon. This results in dark brown Ah colours when dry. These soi' are classified as Orthic Dark Browns as they also have a B horizon.

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* Van Ryswyk also noted the presence of ash in an organic deposit on Opax Mt.

Above the Interior bunch grass zone in the study area, some higher elevation grasslands exist alongside forests of Douglas-fir. These grassland soils contain black Ah horizons high in organic matter, and are classified as Orthic Blacks as they also have a B horizon.

Immediately to the east of the study area, van Ryswyk et al. (1966) found that Orthic Browns occur to about 610 m and coincided closely with the Lower (Agropyron-Artemisia) grasslands; that Orthic Dark Browns extend to about 825 m elevations and coincide closely with the Middle (Agropyron-Poa) grasslands; and that Orthic Blacks occur to about 1000 m and coincide closely with the Upper (Agropyron-Festuca) grasslands. The ten field observations in the grasslands of the study area tended to support these elevational breaks.

Brunisolic soils generally have weakly expressed soil horizonation and occur dominantly under forests of ponderosa pine and Douglas-fir. Bluebunch wheat grass is common in the understory; pine grass also occurs in the higher elevation sites.

When these forests have relatively closed canopies, thereby limiting the extent of bluebunch wheat grass, an organic enriched mineral surface horizon (Ah) is either thin or absent. These soils are classified as Orthic Eutric Brunisols due to the relatively neutral pH of the B horizon. These soils are most common in the Interior Douglas-fir zone, ponderosa pine subzone, between 600 and 1050 m elevations.

Where forests have very open canopies, thereby allowing a relatively dense cover of bluebunch wheat grass, a thick Ah horizon is generally present. These soils are classified either as Orthic Dark Browns or as Orthic Melanic Brunisols. The latter soils' Ah have a lower base saturation than Chernozemic Ah's.

At higher elevations, above the limits of ponderosa pine, other Brunisolic subgroups, such as Eluviated Eutric or Dystric Brunisols can be also

found but are not common. These soils generally have a light coloured eluviated Ae horizon, and are slightly to moderately acid in reaction.

Luvisolic soils are characterized by a horizon of clay accumulation. This horizon, when strongly expressed, can inhibit downward water movement and root penetration in the soil. Luvisols are the most common soil order in the forests of the study area, especially above the limits of ponderosa pine above approximately 1000 m elevation.

Where stands of Douglas-fir with lodgepole pine exist, Brunisolic Gray Luvisols are most common, particularly on the widely found medium textured morainal materials. Some Orthic Gray Luvisols can also be encountered here. In higher elevations forests (above 1400 m) with Engelmann spruce and alpine fir, Podzolic Gray Luvisols predominate.

Organic soils are scattered, as mentioned, throughout the higher plateaus of the study area. Soil subgroups vary considerably from area to area.

Gleysolic soils are mineral soils saturated with water for much of the growing season. Although no Gleysolic soils were mapped for the area, one site was observed adjacent to Organic soils.

Regosolic soils lack a B horizon. Regosols exist as map inclusions with some fluvial soils (denoted by an "x" following the soil type symbol - e.g. F5x), since their extent is confined to small drainage channels which are periodically inundated. Orthic Regosols occur on weathered bedrock sites mapped as "CO", located at lower elevations, and on the dry bottoms of lakes and ponds which occasionally fill with water (LO). Active talus slopes with little or no vegetative cover also have Regosolic soils.

Podzolic soils are characterized in the study area by accumulations of iron and aluminum in the B horizon, resulting in a Bf horizon. These soils

occur under Engelmann spruce and alpine fir or seral lodgepole pine on some coarse-textured colluvial deposits.

3.5 SOIL CLIMATE

Soil temperature classes and soil moisture subclasses, as defined by The Canada Soil Survey Committee (1978) and Clayton et al. (1977), were estimated for the study area using methods discussed by Vold and Marsh (1981) and data provided by R. Williams. Soil temperature classes are based mainly on mean annual and mean seasonal soil temperature and on the length of the growing season. Soil moisture subclasses are mainly based on water deficits during the growing season.

Soil temperature at 50 cm depth was estimated throughout the year from a series of empirical equations developed by Ouellet (1973). These equations estimate soil temperature using mean daily air temperature, mean rainfall and mean snowfall. Appendix A on climate provides estimates of monthly mean temperature and monthly mean soil temperatures at 50 cm depth for a variety of elevations. In the study area, estimated mean annual soil temperature at 50 cm exceeded estimated mean annual air temperature by between 1.5 and 2.2°C.

Table 3.1 summarizes the estimated mean annual and mean summer (July to September) soil temperature at 50 cm for the study area, with the appropriate soil temperature class given for each parameter. Other parameters that help characterize soil temperature classes are also shown; these data have also been summarized from climate tables in the Appendix A.

Soil moisture subclasses were determined by estimating water deficits and the climatic moisture index for deep, loamy soils on a variety of elevations, slopes and aspects. Water deficits can be defined as the difference between potential evapotranspiration (PET) and precipitation (PPT) and soil moisture (SM) available to plants at the beginning of the growing season

assuming no losses due to runoff or drainage, or no additions due to seepage or upward soil water movement. Table 3.2a summarizes some of this estimated data (see climate tables in Appendix A) for sites on three selected aspects. SM was estimated and extrapolated using data collected by Van Ryswyk (pers. comm.) and van Ryswyk and Broersma (1977) for two different grassland sites.

Table 3.2b provides estimates of water deficits (WD) and climatic moisture index (CMI) for the three selected aspects at a variety of elevations. CMI was determined by dividing PET into PPT x 100 (Vold and Marsh, 1981). The appropriate soil moisture subclass for both WD and CMI estimates are also shown.

TABLE 3.1
ESTIMATED SOIL TEMPERATURE CLASSES

Elev. (m)	MAST	MSST	DD> 5°C	Days > 5°C	Days > 15°C	Est'd STC
400	10.4 mild	20.0 mild	1949 mild	260 mild	110 mild	mild
600	9.2 mild	18.0 mild-cool	1735 mild	240 mild	90 mild	mild
800	8.0 mild-cool	16.2 mild-cool	1522 cool	210 mild-cool	70 cool	cool
1000	6.9 cool-cold	14.5 cold	1309 cool	190 cool-cold	50 cold	cool
1200	5.7 cool-cold	12.8 cold	1096 cold	180 cool-cold	0 cold-v. cold	cold
1400	4.7 cold	11.4 cold	882 cold	160 cold	0 cold-v. cold	cold
1600	3.9 cold	10.4 cold	669 cold	140 cold	0 cold-v. cold	cold
1800	3.4 cold	9.8 cold	456 v. cold	120 cold-v. cold	0 cold-v. cold	cold

MAST = mean annual soil temperature at 50 cm in °C
MSST = mean summer (July-Sept.) soil temperature at 50 cm in °C
DD> 5°C = degree - days greater than 5°C.
STC = soil temperature class.

TABLE 3.2a

BACKGROUND DATA FOR SOIL MOISTURE SUBCLASS ESTIMATES

Elev. (m)	PET (cm)*	PPT (cm)*	CMD (cm) (PET-PPT)	SM (cm)	Aspect
400	70.5	13.2	57.3	4	South,
600	68.6	15.7	52.9	5	20°
800	66.4	18.3	48.1	6	Slope
1000	58.0	18.4	39.6	7	
1200	56.0	20.5	35.5	8	
1400	54.1	22.6	31.5	9	
1600	52.1	24.7	27.4	9	
1800	50.1	26.9	23.2	9	
400	64.3	13.2	51.1	4	None,
600	62.5	15.7	46.8	5	0°
800	60.4	18.3	42.1	6	Slope
1000	52.5	18.4	34.1	7	(level)
1200	50.7	20.5	30.2	8	
1400	48.9	22.6	26.3	9	
1600	47.1	24.7	22.4	9	
1800	45.2	26.9	18.3	9	
400	50.0	13.2	36.8	4	North,
600	48.3	15.7	32.0	5	20°
800	46.3	18.3	28.0	6	Slope
1000	39.9	18.4	21.5	7	
1200	38.4	20.5	17.9	8	
1400	37.0	22.6	14.4	9	
1600	35.5	24.7	10.8	9	
1800	34.0	26.9	7.1	9	

* For April to Sept. at 400 - 800 m elev., and May to Sept. at 1000 - 1800 m elevation.

TABLE 3.2b

ESTIMATED SOIL MOISTURE SUBCLASSES

Elev. (m)	20° Slope South Aspect		0° Level No Aspect		20° Slope North Aspect	
	WD (cm)	CMI	WD (cm)	CMI	WD (cm)	CMI
400	53.3 arid	19 arid	47.1 subarid	21 arid	32.8 subarid	27 subarid
600	47.9 subarid	23 arid	41.8 subarid	25 subarid	27.5 subarid	33 subarid
800	42.1 subarid	27 subarid	36.1 subarid	30 subarid	22.0 subarid	40 subarid
1000	32.6 subarid	32 subarid	27.1 subarid	35 subarid	14.5 semiarid	46 semiarid
1200	28.5 subarid	37 subarid	22.2 subarid	40 subarid	9.9 subhumid	53 semiarid
1400	22.5 subarid	42 subarid	17.3 semiarid	46 semiarid	5.4 humid	61 subhumid
1600	18.4 semiarid	47 semiarid	13.4 semiarid	52 semiarid	1.8 perhumid	70 subhumid
1800	14.2 semiarid	54 semiarid	9.3 semiarid	60 subhumid	0 perhumid	79 humid

WD = Water deficits = CMD - SM (see Table 2).
CMI = Climatic moisture index = $\frac{P \times 100}{PET}$

Note: The growing season for estimating water deficits was considered to be April to September for 400 - 800 m elevation, and May to September for 1000 - 1800 m elevation. The above estimates are for deep, loamy soils.

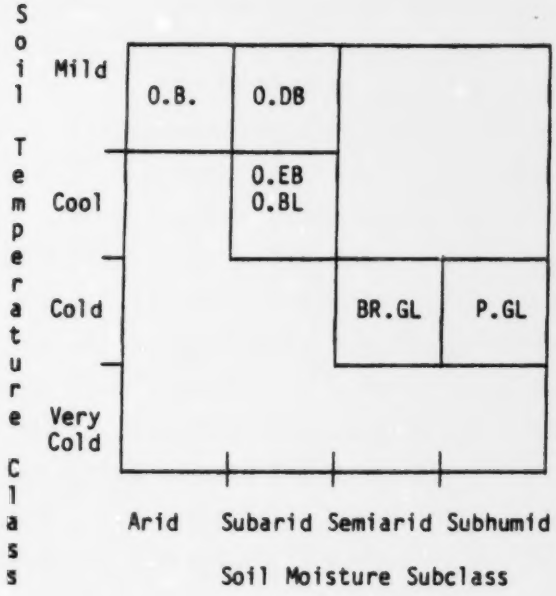
Table 3.3 summarizes both estimated soil temperature classes and soil moisture subclasses for a variety of elevations, slopes and aspects in the study area. These estimates served as benchmark sites when assessing soil climate for particular soils. Soil moisture subclass estimates, in particular, were modified when coarse, shallow soils on steep slopes were encountered. In these areas drier subclasses were often assigned, due to smaller SM values and the possibility of surface runoff or ground water losses, thereby resulting in higher actual water deficits.

TABLE 3.3
SOIL CLIMATE ESTIMATES

Elev. (m)	South Aspect 20° Slope	No Aspect 0° - level	North Aspect 20° Slope
400	mild, arid	mild, subarid	mild, subarid
600	mild, subarid	mild, subarid	mild, subarid
800	cool, subarid	cool, subarid	cool, subarid
1000	cool, subarid	cool, subarid	cool, semiarid
1200	cold, subarid	cold, subarid	cold, subhumid
1400	cold, subarid	cold, semiarid	cold subhumid
1600	cold, semiarid	cold, semiarid	cold, humid
1800	cold, semiarid	cold, semiarid	cold, humid

TABLE 3.4

GENERAL RELATIONSHIP BETWEEN SOIL CLIMATE,
SOIL SUBGROUP, AND VEGETATION SUBZONE
ON MESIC SITES



	Dominant Soil Subgroup	Vegetation Subzone
O.B	Orthic Brown	Interior bunch grass zone
O.DB	Orthic Dark Brown	Interior bunch grass zone
O.BL	Orthic Black	Upper Grasslands (seral) in Interior Douglas-fir zone: ponderosa pine subzone
O.EB	Orthic Eutric Brunisol	Interior Douglas-fir zone: ponderosa pine subzone
BR.GL	Brunisolic Gray Luvisol	Interior Douglas-fir zone: lodgepole pine subzone.
P.GL	Podzolic Gray Luvisol	Subalpine Engelmann spruce-alpine fir zone: Douglas-fir - lodgepole pine subzone.

Table 3.4 illustrates general relationships between soil climate classes, soil subgroups, and dominant vegetation based on coincident position in the landscape.

The only check on these estimated soil climate classes in the field were soil temperature measurements at 50 cm depth to assess mean summer soil temperatures for the year of the field work (1981). These observations are listed on Table 3.5a. Average values are shown on Table 3.5b and compared to the estimated values from Table 3.1. In general, measured average summer soil temperatures in 1981 compared very well with the estimated values.

TABLE 3.5a

SOIL TEMPERATURE MEASUREMENTS AT 10 AND 50 cm DEPTH in °C

Approximate Elevation (m)	Soil Temperature 10 cm	50 cm	Date (1981)	Soil Type	Vegetation Zone*
400	18	21	Sept 21	F1	IBG
400	19	21	Sept 21	F1	IBG
423	25	23	July 24	F1	IBG
500	17	20	Sept 21	L1	IBG
680	20	20	July 29	LO	IBG
657	21	20	July 24	M2	IBG
700	17	15	July 25	F4x	IDa
795	17	16	July 25	M4	IDa
850	15	17	Sept 27	C2	IDa
855	14	13	Sept 24	L3	IDa
860	22	20	July 24	M3	IDa
864	18	18	July 25	C4	IDa
900	13	14	Sept 24	M2	IDa
936	22	22	July 27	M4	IDa
1000	10	12	Sept 26	M4	IDa
1050	18	16	July 23	C4	IDa
1050	26	24	July 27	M4	IDa
1020	16	16	July 26	M5	IDb
1071	14	13	July 23	F5	IDb
1092	17	16	July 23	F5	IDb
1050	12	13	Sept 24	M5	IDb
1125	16	14	Sept 29	F5	IDb
1130	17	16	July 23	F5	IDb
1200	10	12	Sept 23	M5	IDb
1220	12	11	July 25	M5	IDb
1215	20	20	July 29	F5	IDb
1250	20	17	July 26	M5	IDb
1251	20	19	July 27	M5	IDb
1200	16	15	July 26	M5	IDb
1287	12	13	July 26	C5v	IDb
1305	16	15	July 26	M5	IDb
1300	11	9	Sept 24	M5	IDb
1400	10	14	Sept 26	M5	IDb
1365	10	12	Sept 21	M6	SAeS-alF
1485	15	13	July 28	M6	SAeS-alF
1518	10	9	July 28	M6	SAeS-alF
1640	10	11	Sept 21	M6	SAeS-alF
1600	10	10	Sept 26	M6	SAeS-alF

* IBG - Interior bunch grass zone
IDa - Interior Douglas-fir zone:ponderosa pine subzone
IDb - Interior Douglas-fir zone:lodgepole pine subzone
SAeS-alF - Subalpine Engelmann spruce - alpine fir zone

TABLE 3.5b
AVERAGE OBSERVED SUMMER SOIL TEMPERATURES AT 50 cm, 1981

Elevation	Measurements	Average SST		Estimated MSST		Vegetation Zone
400 m	3	22	mild	20.0	mild	IBG
600 m	3	20	mild	18.0	mild-cool	IBG
800 m	8	17	mild-cool	16.2	mild-cool	IDa
1000 m	7	16	mild-cool	14.5	cold	IDa+b
1200 m	12	16	mild-cool	12.8	cold	IDb
1400 m	3	13	cold	11.4	cold	SAeS-alF+IDb
1600 m	3	10	cold	10.4	cold	SAeS-alF

SST - Recorded 1981 Summer Soil Temperature (°C) at 50 cm
MSST - Mean Summer Soil Temperature (July-Sept) at 50 cm in °C (from Table 3.1)

In general, actual measurements tended to be higher by 2°C (ranging from 0.4° C to 3.2° C) than estimated values for each elevational grouping (e.g. 400 m, 600 m). Since the 1981 summer did not appear to be abnormally warm, differences could be accounted for by use of an inexpensive pocket soil thermometer, or by the fact measurements were always taken during the day and not at night.

3.6 SOIL TYPES

For the purposes of mapping, twenty-four 'soil types' were identified. These were differentiated by soil parent materials and soil family characteristics. Table 3.6 provides a key to the soil types. Following the key, each soil is described with a representative soil profile and photograph(s) provided. Note that due to the inherent range of soil properties found within each soil type, deviations from the most common properties can be found. Most of these are discussed with each soil description.

It should be recognized that the reliability of these soil type descriptions vary. Where a large map unit occurs, several field observations have been used in the compilation of the soil type descriptions. However, other soil types identified do not benefit from multi-occurrence observations and may be less accurate summaries. The number of field observation data points used to describe each soil type are as follows:

M1 - 1	F0 - 0	C0 - 1	L0 - 1
M2 - 2	F1 - 3	C1 - 1	L1 - 0
M3 - 3	F2 - 2	C2 - 1	L2 - 0
M4 - 10	F3 - not mapped	C3 - 1	L3 - 1
M5 - 19	F4 - 2	C4 - 5	O1 - 3
M6 - 4	F5 - 12	C5 - 1	
		C6 - 1	

The soil symbols on the map are organized so that "M" is used for all morainal soils, "C" for colluvial, "F" for fluvial, "L" for lacustrine, and "O" for organic soils. The numbers following the soil parent material symbol indicate differences in dominant soil classification as follows: 0 for Regosolic soils (e.g. F0), 1 for Orthic Browns (e.g. M1), 2 for Orthic Dark Browns, 3 for Orthic Blacks, 4 for Orthic Eutric Brunisols, 5 for Brunisolic Gray Luvisols, and 6 for either Podzolic Gray Luvisols or Humo-Ferric Podzols. An exception is "O1" which is used for variable organic soils.

A "v" is added to morainal soils where some shallow-to-bedrock (less than 1 m) deposits exist in the map polygon, and to colluvial soils where shallow deposits are the most common situation (e.g. C2v). An "x" is added to fluvial soils occurring in gully bottoms and supporting riparian vegetation, or to morainal soils receiving significant seepage.

Previous soil survey work in the study area consists of Young and Fenger's (in progress) reconnaissance maps (scale 1:100 000) for the Ashcroft (92I) map sheet area. Soils mapped in this study have been correlated with Young and Fenger's soil associations in Appendix B.

Additional soil survey work in portions of the study area include Agriculture Canada's (1971) 1:50 000 scale preliminary soils map for the Lac du Bois area extending west to Watching Creek, and Belsham's unpublished biophysical 1:50 000 scale map for 92I/16. Just south of the study area, a very detailed survey (scale 1:2400) of the Tranquille Sanatorium Farm was undertaken by van Ryswyk and Dawson (1957), and Sprout and Kelley (1963) completed a detailed soil survey immediately to the west of the study area in lower elevations of the Thompson valley.

In addition to these soil survey projects, soils have been investigated in the Lac du Bois area immediately to the east of the study area by van Ryswyk et al. (1966) and Jakoy (1981). Watson (1977) classified the Lac du Bois rangelands using remote sensing techniques (see also Watson and van Ryswyk, 1980). Parsons et al. (1971) studied soil properties affecting Agropyron and Stipa communities in the Lower grasslands near Kamloops.

The Ministry of Forests have undertaken ecological studies in the Kamloops area (Mitchell, et al. 1981). In their system, biogeoclimatic zones and subzones are recognized that have a broadly homogenous climate. Within each subzone, ecosystem associations are differentiated by a characteristic combination of species and related soil moisture and nutrient regimes; and phases of associations are recognized on the basis of soil texture, slope and aspect differences. Soils mapped in the study area have been broadly correlated with their ecological units in Appendix B.

TABLE 3.6
KEY TO THE SOIL TYPES

The following key provides some general characteristics useful in recognizing the soil types in the field. Soil descriptions should be consulted for verification. Associated vegetation information is applicable to areas that have not been seriously disturbed. For colours, use Munsell colour charts. Materials refer to those in subsoil horizons below 20 cm.

1. Soils developed on morainal (till) parent materials. Coarse fragments are dominantly subrounded and usually 20-50% of material. Wet soil is sticky in hand.

    2. Surface of land is primarily mineral soil rather than forest litter. Grassland soil.

        3. Dry surface soil is brown M1
        3. Dry surface soil is dark brown M2
        3. Dry surface soil is black M3

    2. Surface of land is primarily covered with forest litter rather than exposed mineral soil.

        4. Forest litter contains Ponderosa pine needles (Ah present)...M4
        4. Forest litter contains Douglas-fir and/or lodgepole pine needles (Ah usually absent); moist surface soil colour at 10 cm is brown to dark brown M5
        4. Forest litter contains alpine fir, spruce and/or lodgepole pine needles (Ah absent); moist surface soil colour at 10 cm below litter is reddish brown M6

1. Soils developed on colluvial parent materials. Coarse fragments are dominantly angular and usually 30 to 70% of material. Wet soil is usually non-sticky to slightly sticky in hand.

TABLE 3.6 (continued)

5. Surface of land is primarily mineral soil rather than forest litter.

6. Land surface is all mineral soil; essentially no vegetation exists; surface soil fizzes (reacts) when dilute HCl acid applied C0

6. Land surface is primarily exposed mineral soil, but with some shrub litter; shrubs and grasses exist.

7. Dry surface soil is brown C1

7. Dry surface soil is dark brown C2

7. Dry surface soil is black C3

5. Surface of land is primarly covered with forest litter rather than exposed mineral soil.

8. Forest litter contains ponderosa pine needles (Ah present)...C4

8. Forest litter contains Douglas-fir and/or lodgepole pine needles (Ah usually absent); moist surface soil colour at 10 cm is brown to dark brown C5

8. Forest litter consists primarily of spruce, alpine fir and/or lodgepole pine needles (Ah absent), moist surface soil colour at 10 cm below litter is reddish brown C6

1. Soils developed on fluvial parent materials. Coarse fragments are dominantly rounded. Wet soil is usually non-sticky. Soil at 50 cm is predominantly "grainy" in feel indicating mainly sand.

9. Land surface is primarily mineral soil; surface mineral soil fizzes (reacts) when diluted HCl acid applied F0

9. Surface of land is primarily mineral soil rather than forest litter.
Grassland soil.

10. Dry surface soil is brown F1

10. Dry surface soil is dark brown F2

10. Dry surface soil is black F3

TABLE 3.6 (continued)

9. Surface of land primarily covered with forest litter rather than exposed mineral soil.

    11. Forest litter contains Ponderosa pine needles (Ah present)...F4
    11. Forest litter contains Douglas-fir and/or lodgepole pine (no Ponderosa pine) needles (Ah usually absent); moist surface soil colour at 10 cm depth is brown to dark brown F5
    11. Forest litter contains primarily leaves from deciduous shrubs and trees; near drainage channel or creek bottom ..see footnote

1. Soils developed on lacustrine parent materials. Coarse fragments usually absent. Wet soil is slightly sticky; soil is not "grainy" (e.g. little sand), but is "gritty" to taste, indicating high silt content.

    12. Land surface is all mineral soil; essentially no vegetation exists; surface soil fizzes (reacts) when dilute acid applied L0
    12. Land surface contains some shrub or grass litter

        13. Dry surface soil is brown L1
        13. Dry surface soil is dark brown L2
        13. Dry surface soil is black L3

1. Soils developed on organic parent material O1

1. Soils less than 10 cm over bedrock .....R

Footnote: Add "x" to those fluvial soils with riparian vegetation which are influenced by seasonally high water tables (e.g. F2x), and to poorly drained morainal soils (e.g. M6x). A "v" is added to those colluvial and morainal soils which are shallow to bedrock.

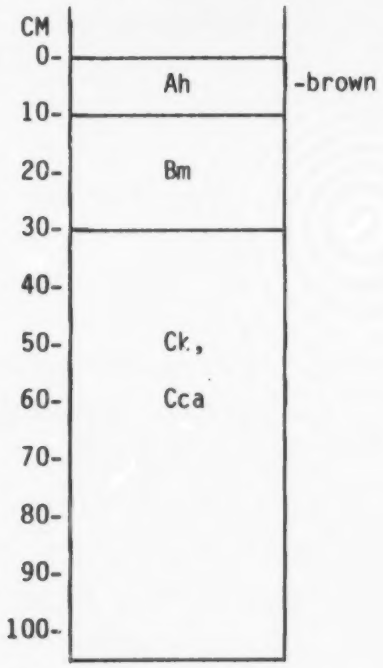
SOIL TYPE: M1

PARENT MATERIAL: Morainal (till)
SOIL FAMILY: Orthic Brown, loamy-skeletal, mixed, mild, arid
SLOPE: 5-45%
ELEVATION: <700 m
DRAINAGE: Well
MOISTURE REGIME: Mesic
NUTRIENT REGIME: Mesotrophic
HUMUS FORM: Mull
ROOTING DEPTH: 20-40 cm
TEXTURE: Sandy loam to sandy clay loam
COARSE FRAGMENTS: 30-50%, subrounded
SOLUM THICKNESS: 20-40 cm
ZONE/SUBZONE: Interior bunch grass zone
NOTES: Some tills may have fine-loamy particle-size class.

Plate 1 M1 Landscape.

Plate 2 M1 Vegetation.

SOIL PROFILE



SOIL TYPE: M2

PARENT MATERIAL: Morainal (till)

SOIL FAMILY: Orthic Dark Brown, loamy-skeletal, mixed, mild, subarid

SLOPE: 5-45%

ELEVATION: 500-1000 m

DRAINAGE: Well

MOISTURE REGIME: Mesic

NUTRIENT REGIME: Mesotrophic

HUMUS FORM: Mull

ROOTING DEPTH: 30-50 cm

TEXTURE: Loam to sandy clay loam

COARSE FRAGMENTS: 30-50%, subrounded

SOLUM THICKNESS: 30-50 cm

ZONE/SUBZONE: Interior bunch grass zone

NOTES: Some tills may have fine-loamy particle-size class.
Also found in open stands of ponderosa pine.

Plate 3 M2 Vegetation.

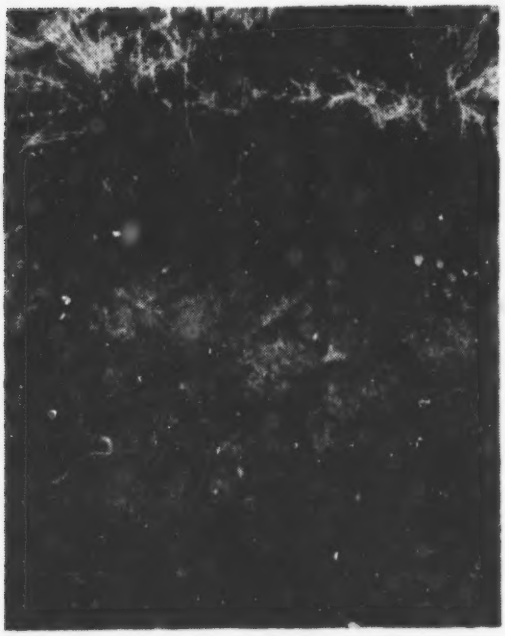
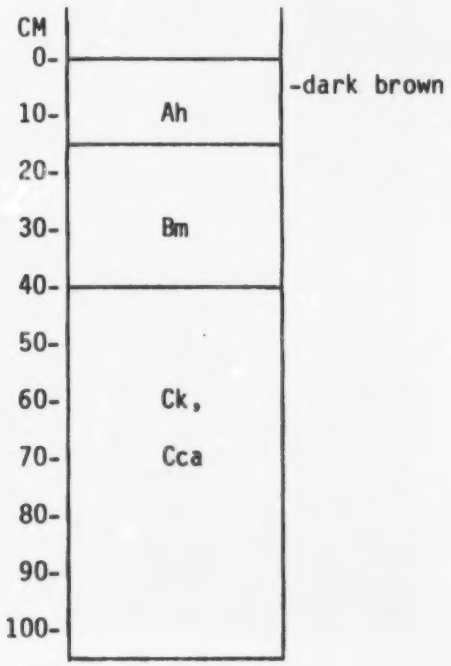


Plate 4 M2 Soil.

SOIL PROFILE



SOIL TYPE: M3

PARENT MATERIAL: Morainal (till)

SOIL FAMILY: Orthic Black, loamy-skeletal mixed, cool, subarid

SLOPE: 5-45%

ELEVATION: 800-1200 m

DRAINAGE: Well to moderately well

MOISTURE REGIME: Mesic to submesic

NUTRIENT REGIME: Mesotrophic

HUMUS FORM: Mull

ROOTING DEPTH: >50 cm

TEXTURE: Loam to sandy clay loam

COARSE FRAGMENTS: 30-50%, subrounded

SOLUM THICKNESS: >50 cm

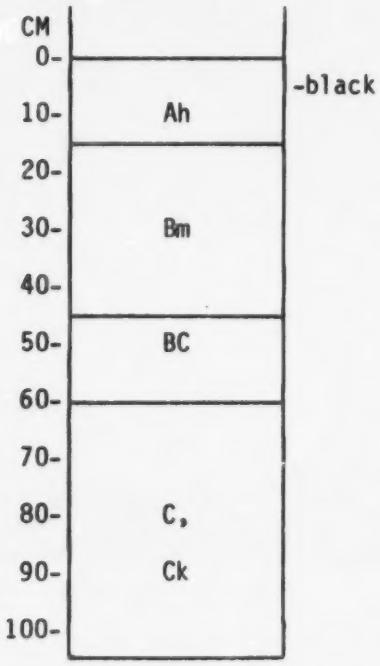
ZONE/SUBZONE: Upper Grasslands in Interior Douglas-fir zone: ponderosa pine subzone

NOTES: Some tills may have fine-loamy particle-size class.
Cold, semiarid soil climates also common.

Plate 5 M3 Vegetation.

Plate 6 M3 Soil.

SOIL PROFILE



SOIL TYPE: M4

PARENT MATERIAL: Morainal (till)

SOIL FAMILY: Orthic Eutric Brunisol, loamy-skeletal, mixed, cool, subarid

SLOPE: 5-45%

ELEVATION: 700-1500 m

DRAINAGE: Well to moderately well

MOISTURE REGIME: Mesic to submesic

NUTRIENT REGIME: Mesotrophic

HUMUS FORM: Moder

ROOTING DEPTH: >50 cm

TEXTURE: Loam to sandy clay loam

COARSE FRAGMENTS: 30-50%, subrounded

SOLUM THICKNESS: >50 cm

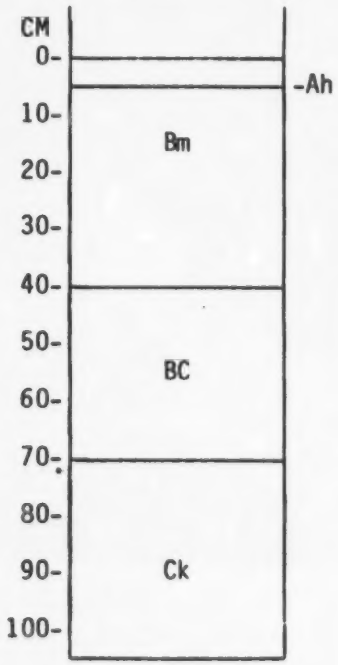
ZONE/SUBZONE: Interior Douglas-fir zone: ponderosa pine subzone

NOTES: Gray Luvisols and Eluviated Eutric Brunisols also common.
Some tills have fine-loamy particle-size class.

Plate 7 M4 Vegetation.

Plate 8 M4 Soil.

SOIL PROFILE



SOIL TYPE: M5

PARENT MATERIAL: Morainal (till)

SOIL FAMILY: Brunisolic Gray Luvisol, loamy-skeletal, mixed, cold, semiarid

SLOPE: 5-45%

ELEVATION: 700-1500 m

DRAINAGE: Moderately well

MOISTURE REGIME: Mesic to submesic

NUTRIENT REGIME: Mesotrophic

HUMUS FORM: Mor

ROOTING DEPTH: >50 cm

TEXTURE: Loam to sandy clay loam

COARSE FRAGMENTS: 30-50%, subrounded

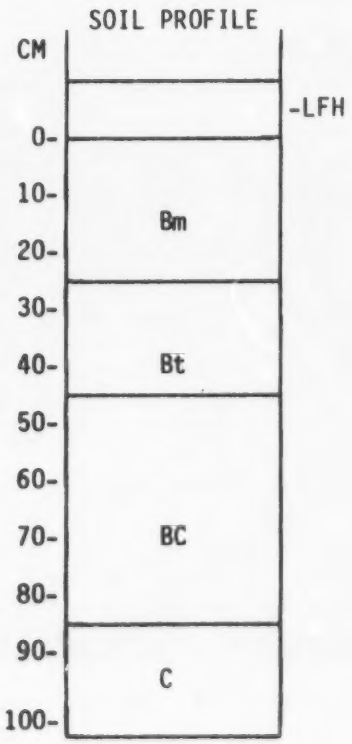
SOLUM THICKNESS: >50 cm

ZONE/SUBZONE: Interior Douglas-fir zone: lodgepole pine subzone

NOTES: Orthic Gray Luvisols also common. Some tills have fine-loamy particle-size class.

Plate 9 M5 Vegetation.

Plate 10 M5 Soil.



SOIL TYPE: M6

PARENT MATERIAL: Morainal (till)

SOIL FAMILY: Podzolic Gray Luvisol, loamy-skeletal, mixed, cold, subhumid

SLOPE: 5-45%

ELEVATION: >1300 m

DRAINAGE: Moderately well

MOISTURE REGIME: Mesic to submesic

NUTRIENT REGIME: Mesotrophic

HUMUS FORM: Mor

ROOTING DEPTH: >50 cm

TEXTURE: Loam

COARSE FRAGMENTS: 30-40%, subrounded

SOLUM THICKNESS: >50 cm

ZONE/SUBZONE: Subalpine Engelmann spruce-alpine fir zone: Douglas-fir - lodgepole pine subzone

NOTES: Some tills have fine-loamy particle-size class.

Plate 11 M6 Vegetation.

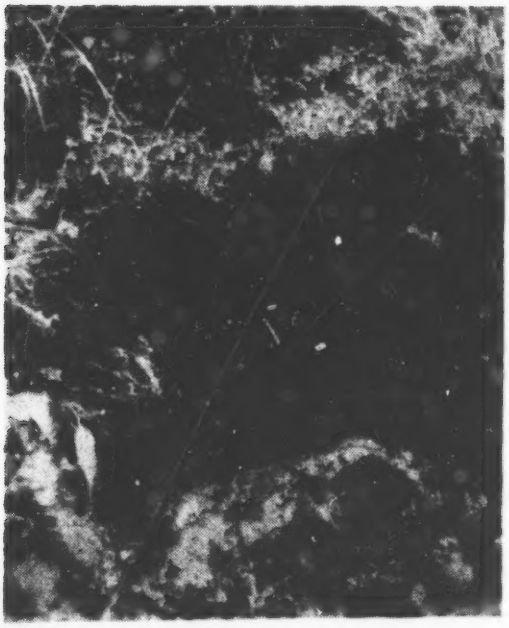
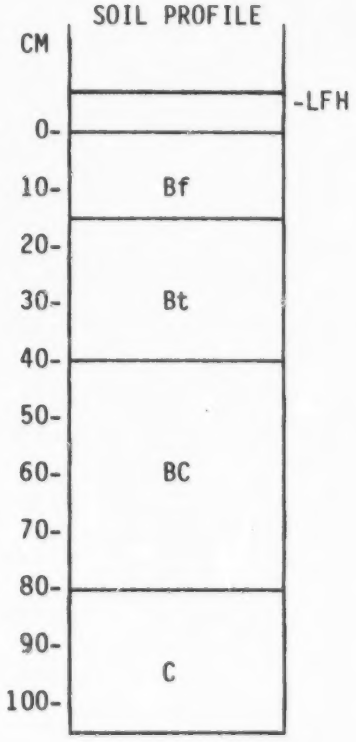


Plate 12 M6 Soil.



SOIL TYPE: CO

PARENT MATERIAL: Colluvium

SOIL FAMILY: Orthic Regosol, loamy-skeletal, mixed, very shallow, mild, arid

SLOPE: >30%

ELEVATION: <900 m

DRAINAGE: Rapid

MOISTURE REGIME: Xeric

NUTRIENT REGIME: Eutrophic

HUMUS FORM: None

ROOTING DEPTH: 0 (unvegetated)

TEXTURE: Loam

COARSE FRAGMENTS: 40-70%, angular

SOLUM THICKNESS: 0

ZONE/SUBZONE: Interior bunch grass zone

NOTES: Soils over weathered bedrock; no or very sparse vegetation.

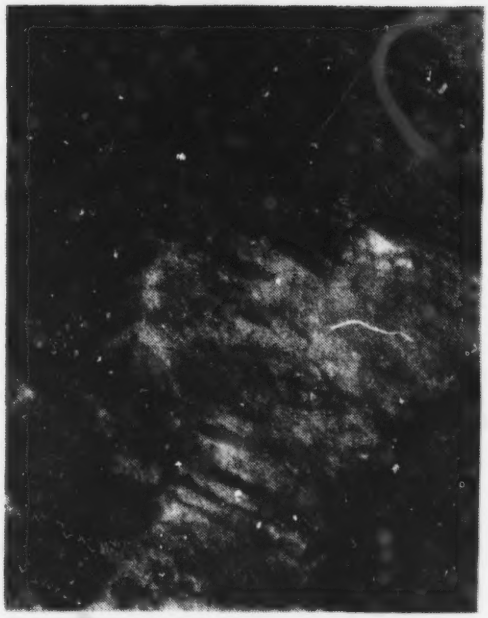
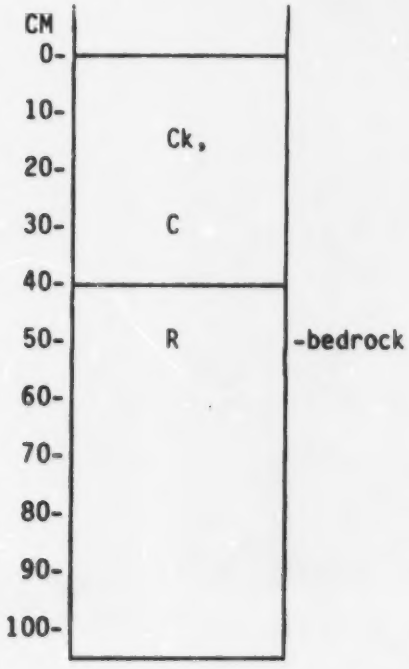


Plate 13 CO Landscape.

SOIL PROFILE



SOIL TYPE: C1

PARENT MATERIAL: Colluvium

SOIL FAMILY: Orthic Brown, loamy-skeletal, mixed, (shallow), mild, arid

SLOPE: >30%

ELEVATION: <700 m

DRAINAGE: Well to rapid

MOISTURE REGIME: Submesic to xeric

NUTRIENT REGIME: Submesotrophic to oligotrophic

HUMUS FORM: Mull

ROOTING DEPTH: 20-40 cm

TEXTURE: Sandy loam to loam

COARSE FRAGMENTS: 40-60%, angular

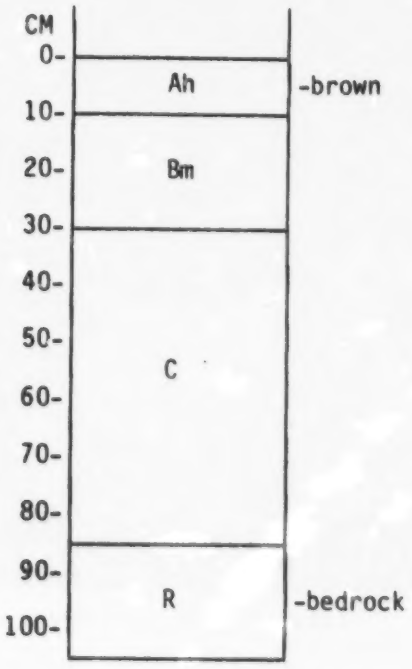
SOLUM THICKNESS: 20-40 cm

ZONE/SUBZONE: Interior bunch grass zone

Plate 14 C1 Landscape.

Plate 15 C1 Vegetation.

SOIL PROFILE



SOIL TYPE: C2

PARENT MATERIAL: Colluvium

SOIL FAMILY: Orthic Dark Brown, loamy-skeletal, mixed, (shallow), mild, subarid

SLOPE: >30%

ELEVATION: 500-1000 m

DRAINAGE: Well to rapid

MOISTURE REGIME: Submesic to xeric

NUTRIENT REGIME: Submesotrophic to oligotrophic

HUMUS FORM: Mull

ROOTING DEPTH: 30-50 cm

TEXTURE: Sandy loam to loam

COARSE FRAGMENTS: 40-60%, angular

SOLUM THICKNESS: 30-50 cm

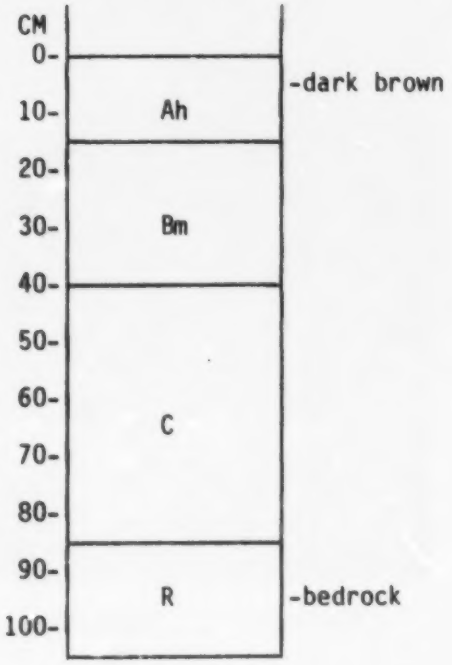
ZONE/SUBZONE: Interior bunch grass zone

NOTES: Also found in open stands of ponderosa pine.

Plate 16 C2 Landscape.

Plate 17 C2 Vegetation.

SOIL PROFILE



SOIL TYPE: C3

PARENT MATERIAL: Colluvium

SOIL FAMILY: Orthic Black, loamy-skeletal, mixed, (shallow), cool, subarid

SLOPE: >30%

ELEVATION: 800-1200 m

DRAINAGE: Well to rapid

MOISTURE REGIME: Submesic to xeric

NUTRIENT REGIME: Submesotrophic to oligotrophic

HUMUS FORM: Mull

ROOTING DEPTH: >50 cm

TEXTURE: Sandy loam to loam

COARSE FRAGMENTS: 40-60%, angular

SOLUM THICKNESS: >50 cm

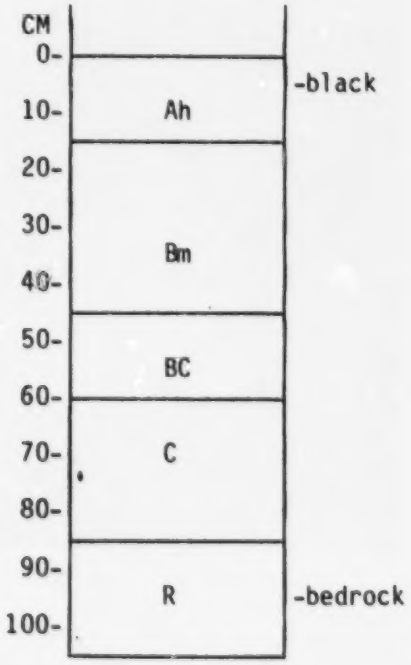
ZONE/SUBZONE: Upper grasslands in Interior Douglas-fir zone: ponderosa pine subzone

NOTES: Cold, semiarid soil climates also common

Plate 18 C3 Vegetation.

Plate 19 C3 Soil.

SOIL PROFILE



SOIL TYPE: C4

PARENT MATERIAL: Colluvium

SOIL FAMILY: Orthic Eutric Brunisol, loamy-skeletal, mixed, (shallow), cool, subarid

SLOPE: >30%

ELEVATION: 700-1500 m

DRAINAGE: Well to rapid

MOISTURE REGIME: Submesic to xeric

NUTRIENT REGIME: Submesotrophic to oligotrophic

HUMUS FORM: Moder

ROOTING DEPTH: >50 cm

TEXTURE: Sandy loam to loam

COARSE FRAGMENTS: 40-60%, angular

SOLUM THICKNESS: >50 cm

ZONE/SUBZONE: Interior Douglas-fir zone: ponderosa pine subzone

Plate 20 C4 Vegetation.

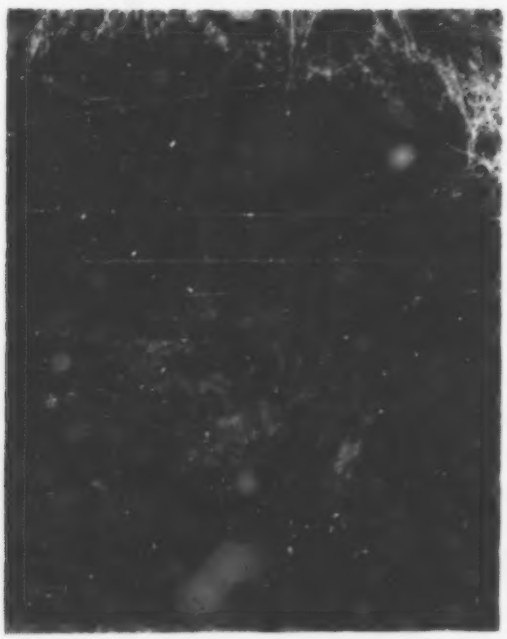
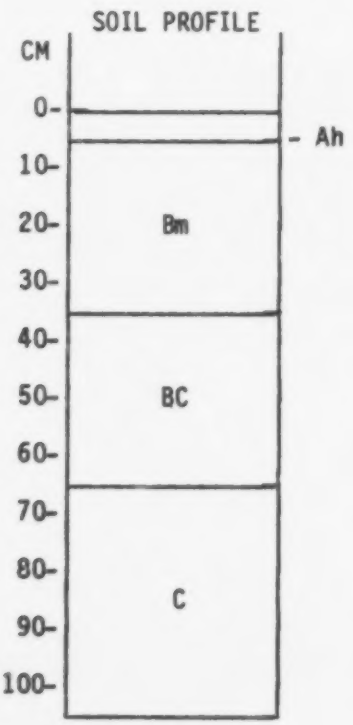


Plate 21 C4 Soil.



SOIL TYPE: C5

PARENT MATERIAL: Colluvium

SOIL FAMILY: Brunisolic Gray Luvisol, loamy-skeletal, mixed, (shallow), cold, semiarid

SLOPE: >30%

ELEVATION: 700-1500 m

DRAINAGE: Well to rapid

MOISTURE REGIME: Submesic to xeric

NUTRIENT REGIME: Submesotrophic to oligotrophic

HUMUS FORM: Mor

ROOTING DEPTH: >50 cm

TEXTURE: Sandy loam to loam

COARSE FRAGMENTS: 40-60%, angular

SOLUM THICKNESS: >50 cm

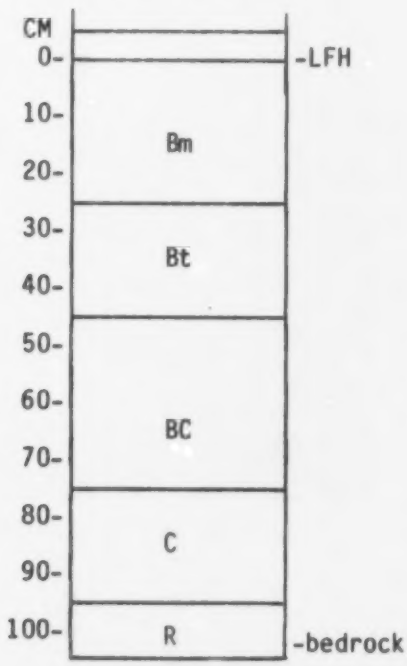
ZONE/SUBZONE: Interior Douglas-fir zone: lodgepole pine subzone

NOTES: Orthic Eutric Brunisols occur on less stable (steeper) slopes

Plate 22 C5 Vegetation.

Plate 23 C5 Soil.

SOIL PROFILE

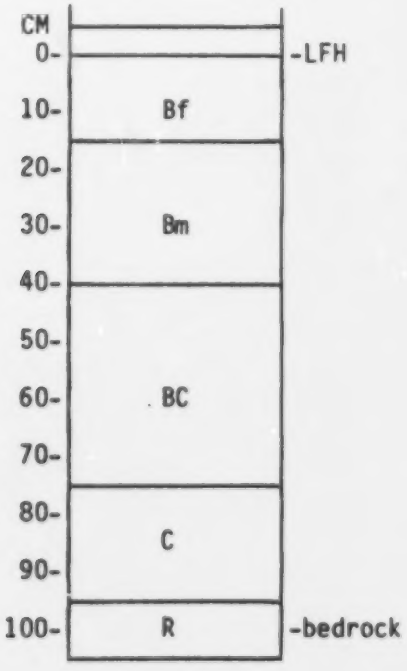


SOIL TYPE: C6

PARENT MATERIAL: Colluvium
SOIL FAMILY: Orthic Humo-Ferric Podzol, loamy-skeletal, mixed, (shallow), cold, subhumid
SLOPE: >30%
ELEVATION: >1300 m
DRAINAGE: Well to rapid
MOISTURE REGIME: Submesic to xeric
NUTRIENT REGIME: Submesotrophic to oligotrophic
HUMUS FORM: Mor
ROOTING DEPTH: >50 cm
TEXTURE: Sandy loam to loam
COARSE FRAGMENTS: 40-60%, angular
SOLUM THICKNESS: >50 cm
ZONE/SUBZONE: Subalpine Engelmann spruce-alpine fir zone: Douglas-fir - lodgepole pine subzone
NOTES: Orthic Dystric Brunisols and Podzolic Gray Luvisols also occur; the former on dry, shallow soils, the latter on deeper, stable materials.

Plate 24 C6 Landscape.

SOIL PROFILE



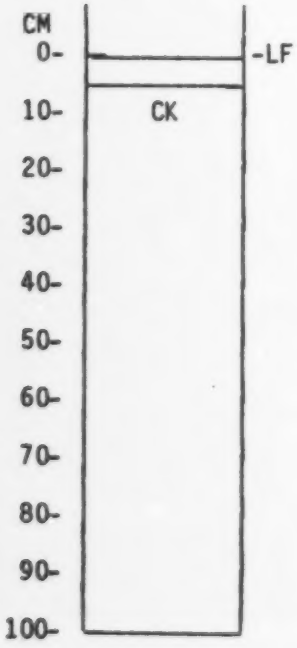
SOIL TYPE: FO

PARENT MATERIAL: Fluvial (floodplain)
SOIL FAMILY: Orthic Regosol, sandy or loamy, mixed, mild, semiarid
SLOPE: 0-5%
ELEVATION: <700m
DRAINAGE: Moderately well
MOISTURE REGIME: Hygric to subhygric
NUTRIENT REGIME: Permesotrophic to eutrophic
HUMUS FORM: Variable
TEXTURE: Sandy loam or loamy sand
COARSE FRAGEMENTS: 0-20%, rounded
SOLUM THICKNESS: 10cm
ZONE/SUBZONE: Interior bunch grass zone

Plate 25 FO Landscape.

Plate 26 FO Soil.

SOIL PROFILE



SOIL TYPE: F1

PARENT MATERIAL: Fluvial

SOIL FAMILY: Orthic Brown, sandy-skeletal, mixed, mild, arid

SLOPE: 0-70%

ELEVATION: <700 m

DRAINAGE: Well to rapid

MOISTURE REGIME: Mesic to submesic

NUTRIENT REGIME: Submesotrophic

HUMUS FORM: Mull

ROOTING DEPTH: 20-40 cm

TEXTURE: Sand to sandy loam

COARSE FRAGMENTS: 0-70%, rounded

SOLUM THICKNESS: 20-40 cm

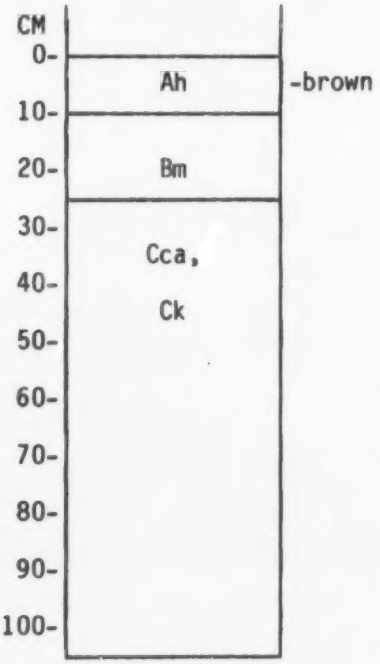
ZONE/SUBZONE: Interior bunch grass zone

NOTES: Flx soils occur along channel bottoms and may have Regosolic profiles with hygric moisture regimes and riparian vegetation

Plate 27 F1 Landscape.

Plate 28 F1 Vegetation.

SOIL PROFILE



SOIL TYPE: F2

PARENT MATERIAL: Fluvial

SOIL FAMILY: Orthic Dark Brown, sandy-skeletal, mixed, mild, subarid

SLOPE: 0-70%

ELEVATION: 500-1000 m

DRAINAGE: Well to rapid

MOISTURE REGIME: Mesic to submesic

NUTRIENT REGIME: Submesotrophic

HUMUS FORM: Mull

ROOTING DEPTH: 20-50 cm

TEXTURE: Sand to sandy loam

COARSE FRAGMENTS: 0-70%, rounded

SOLUM THICKNESS: 20-50 cm

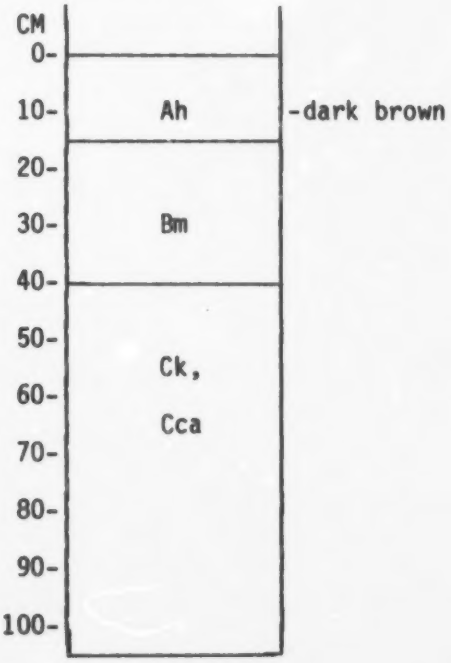
ZONE/SUBZONE: Interior bunch grass zone

NOTES: Also found on open stands of ponderosa pine. F2x soils occur along channel bottoms and may have Regosolic profiles with hygric moisture regimes and riparian vegetation

Plate 29 F2 Landscape.

Plate 30 F2 Vegetation.

SOIL PROFILE



SOIL TYPE: F3

PARENT MATERIAL: Fluvial

SOIL FAMILY: Orthic Black, sandy-skeletal, mixed, cool, subarid

SLOPE: <30%

ELEVATION: 800-1200 m

DRAINAGE: Well to rapid

MOISTURE REGIME: Submesic to subxeric

NUTRIENT REGIME: Submesotrophic

HUMUS FORM: Mull

ROOTING DEPTH: >50 cm

TEXTURE: Sand to sandy loam

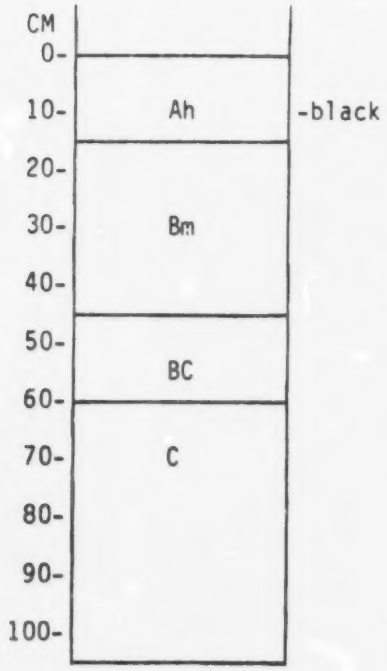
COARSE FRAGMENTS: 0-70%, rounded

SOLUM THICKNESS: >50 cm

ZONE/SUBZONE: Upper grasslands in Interior Douglas-fir zone: ponderosa pine subzone.

NOTES: Cold, semiarid soil climates also common

SOIL PROFILE



SOIL TYPE: F4

PARENT MATERIAL: Fluvial

SOIL FAMILY: Orthic Eutric Brunisol, sandy-skeletal, mixed, cool, subarid

SLOPE: <30%

ELEVATION: 700-1500 m

DRAINAGE: Well to rapid

MOISTURE REGIME: Mesic to submesic

NUTRIENT REGIME: Submesotrophic

HUMUS FORM: Moder

ROOTING DEPTH: >50 cm

TEXTURE: Sand to sandy loam

COARSE FRAGMENTS: 0-70%, rounded

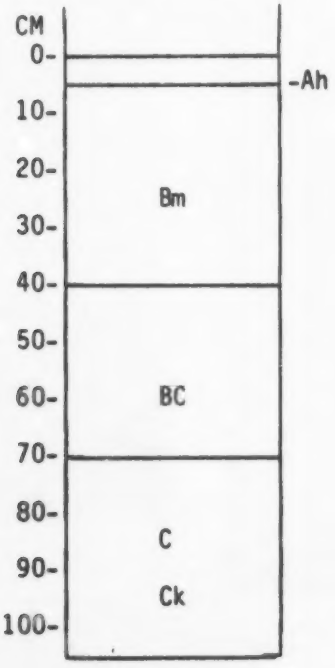
SOLUM THICKNESS: >50 cm

ZONE/SUBZONE: Interior Douglas-fir zone: ponderosa pine subzone

NOTES: F4x soils occur along channel bottoms and have Regosolic profiles with hygric moisture regimes and riparian vegetation

Plate 31 F4 Vegetation.

SOIL PROFILE



SOIL TYPE: F5

PARENT MATERIAL: Fluvial

SOIL FAMILY: Brunisolic Gray Luvisol, sandy-skeletal, mixed, cold, semiarid

SLOPE: <30%

ELEVATION: 700-1500 m

DRAINAGE: Well to rapid

MOISTURE REGIME: Subhygric to submesic

NUTRIENT REGIME: Submesotrophic

HUMUS FORM: Mor

ROOTING DEPTH: >50 cm

TEXTURE: Sand to sandy loam

COARSE FRAGMENTS: 0-70%, rounded

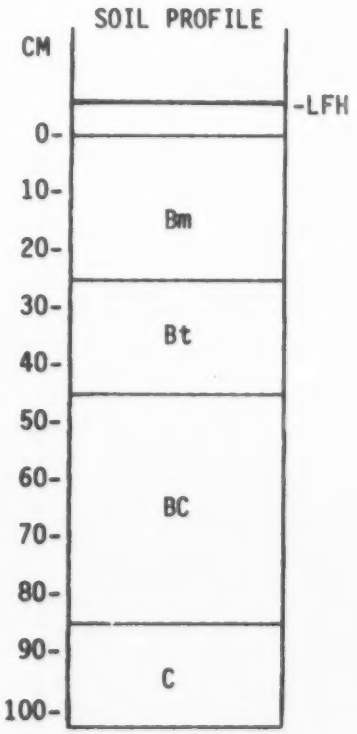
SOLUM THICKNESS: >50 cm

ZONE/SUBZONE: Interior Douglas-fir zone: lodgepole pine subzone

NOTES: Orthic Eutric Brunisols also occur. F5x contain some soils along channel bottoms that may have Regosolic profiles with hygric moisture regimes and riparian vegetation

Plate 32 F5 Vegetation.

Plate 33 F5 Vegetation.



SOIL TYPE: LO

PARENT MATERIAL: Lacustrine

SOIL FAMILY: Orthic Regosol, coarse-silty, mixed, mild, subarid

SLOPE: 0-5%

ELEVATION: <1000 m

DRAINAGE: Moderately well to imperfect

MOISTURE REGIME: Mesic

NUTRIENT REGIME: Oligotrophic

HUMUS FORM: None

ROOTING DEPTH: 0 (unvegetated)

TEXTURE: Silt to silt loam

COARSE FRAGMENTS: 0

SOLUM THICKNESS: 0

ZONE/SUBZONE: Interior bunch grass zone

NOTES: Seasonally dry lake floor with salts at soil surface. Little, if any, vegetation present.

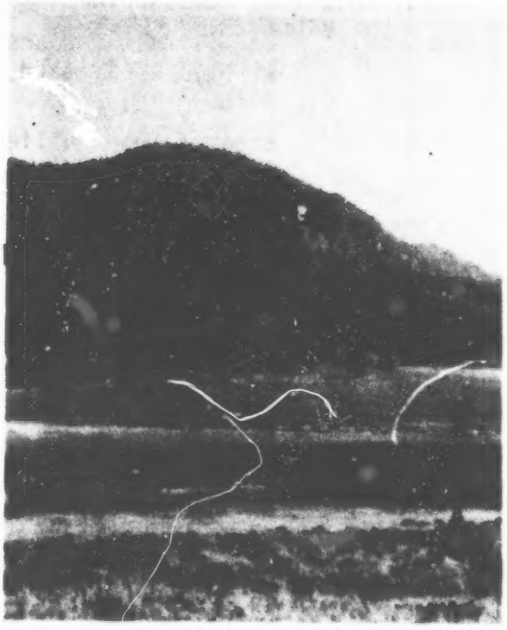
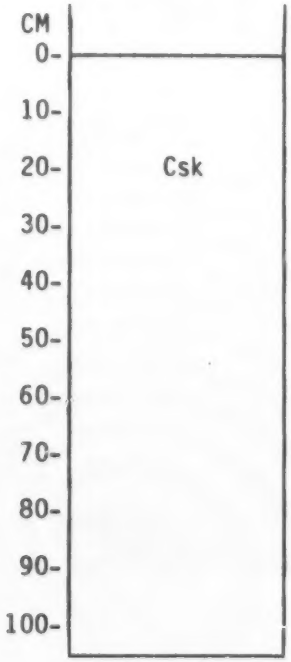


Plate 34 LO Landscape.

Plate 35 LO Vegetation.

SOIL PROFILE



SOIL TYPE: L1

PARENT MATERIAL: Lacustrine

SOIL FAMILY: Orthic Brown, coarse-silty, mixed, mild, arid

SLOPE: <15%; steeper when gullied

ELEVATION: <700 m

DRAINAGE: Well

MOISTURE REGIME: Mesic

NUTRIENT REGIME: Mesotrophic

HUMUS FORM: Mull

ROOTING DEPTH: 20-40 cm

TEXTURE: Silt to silt loam

COARSE FRAGMENTS: 0

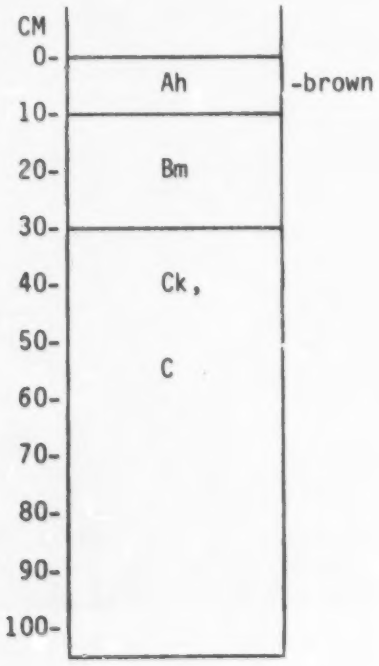
SOLUM THICKNESS: 20-40 cm

ZONE/SUBZONE: Interior bunch grass zone

Plate 36 L1 Vegetation.

Plate 37 L1 Soil.

SOIL PROFILE



SOIL TYPE: L2

PARENT MATERIAL: Lacustrine

SOIL FAMILY: Orthic Dark Brown, coarse-silty, mixed, mild, subarid

SLOPE: <15%; steeper when gullied

ELEVATION: 500-1000 m

DRAINAGE: Well

MOISTURE REGIME: Mesic

NUTRIENT REGIME: Mesotrophic

HUMUS FORM: Mull

ROOTING DEPTH: 30-50 cm

TEXTURE: Silt to silt loam

COARSE FRAGMENTS: 0

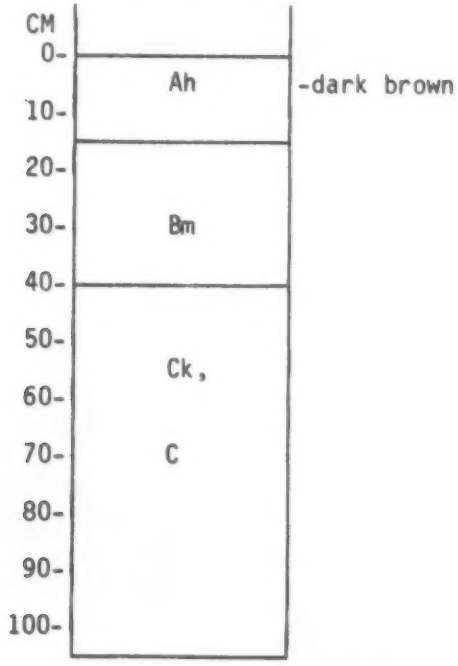
SOLUM THICKNESS: 30-50 cm

ZONE/SUBZONE: Interior bunchgrass zone

NOTES: Also found in open stands of ponderosa pine.

Plate 38 L2 Landscape.

SOIL PROFILE



SOIL TYPE: L3

PARENT MATERIAL: Lacustrine

SOIL FAMILY: Orthic Black, coarse-silty, mixed, cool, subarid

SLOPE: <15%

ELEVATION: 800-1200 m

DRAINAGE: Well to moderately well

MOISTURE REGIME: Mesic to subhygric

NUTRIENT REGIME: Mesotrophic

HUMUS FORM: Mull

ROOTING DEPTH: >50 cm

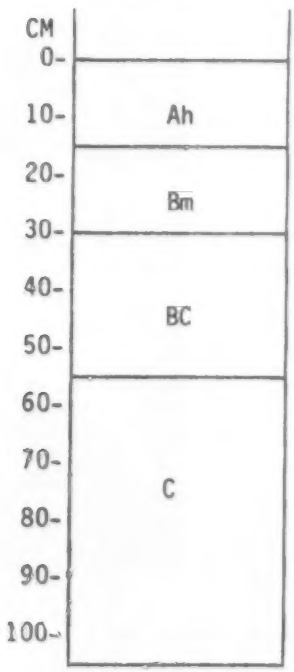
TEXTURE: Silt to silt loam

COARSE FRAGMENTS: 0

SOLUM THICKNESS: >50 cm

ZONE/SUBZONE: Upper grassland in Interior Douglas-fir zone; ponderosa pine subzone

SOIL PROFILE



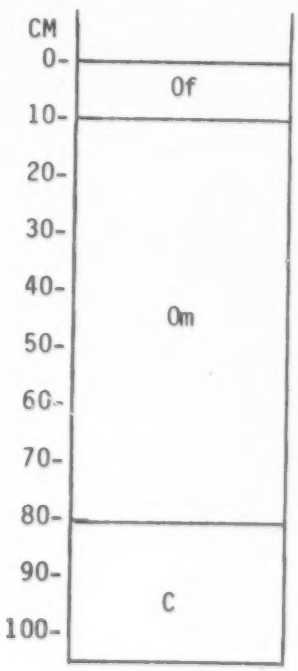
SOIL TYPE: 01

PARENT MATERIAL: Organic
SOIL FAMILY: Variable
SLOPE: <5%
ELEVATION: Variable
DRAINAGE: Very poor to poor
MOISTURE REGIME: Hydric
NUTRIENT REGIME: Variable
HUMUS FORM: Variable
ROOTING DEPTH: Variable
TEXTURE: Peaty
COARSE FRAGMENTS: 0
SOLUM THICKNESS: Variable
ZONE/SUBZONE: All subzones, but primarily in Subalpine Engelmann spruce-alpine fir zone: Douglas-fir - lodgepole pine subzone.
NOTES: Some soils are Gleysolic where organic material is 15 to 40 cm thick.

Plate 39 01 Vegetation.

Plate 40 01 Soil.

SOIL PROFILE



3.7 SOIL INTERPRETATIONS

3.7.1 UNIFIED SOIL CLASS

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit and organic matter content. Fifteen soil classes are recognized: there are eight classes for coarse-grained soils (GW, GP, GM, GC for gravelly materials and SW, SP, SM, and SC for sandy materials); six classes for fine-grained soils (ML, CL, OL, MH, CH and OH); and one class for organic soils identified as Pt.

By knowing the Unified soil class, many engineering characteristics can be inferred, including the soils' value as subgrade, its shear strength, compressibility and expansion characteristics, compaction characteristics and potential for frost action. These inferred engineering characteristics are presented in Table 3.7 for each Unified soil class.

TABLE 3.7

ENGINEERING CHARACTERISTICS OF UNIFIED SOIL GROUPS[1]

Soil Type	Unified Soil Group	Value as Subgrade	Shear Strength	Compressibility and Expansion	Compaction Characteristics	Frost Action Potential
F0 to F5	GP	Good to excellent	High	Almost none	Good	None to very slight
C0 to C6	GM	Good to excellent	High to medium	Very slight to slight	Good	Slight to medium
F0 to F5	SP	Good to fair	Medium	Almost none	Good to fair	None to slight
C0 to C6	SM	Good to fair	Medium	Very slight to medium	Good to fair	Slight to high
M1 to M6	SC	Fair to good	Medium to low	Slight to medium	Fair	Slight to high
L0 to L3	ML	Fair to poor	Medium to low	Slight to medium	Fair to poor	Medium to very high
L0 to L3	MH	Poor	Low	High	Poor to very poor	Medium to very high
01	Pt	Unsuitable	Very low	Very high	Fair to poor	Slight

[1] This chart is adapted from similar tables presented by the USDA Soil Conservation Service (1971), the USDI Bureau of Land Management and the Asphalt Institute (1969).

3.7.2 SOIL ERODIBILITY

Surface erosion is the detachment and subsequent transport of soil particles by running water or wind. Erosion by water commonly results in the formation of gullies or rill complexes, but may be more subtly present as sheet erosion (the removal of a thin layer of soil over an extensive area). Surface erosion can result in the loss of the soil resource, a decrease in site productivity, damage to roads and structures, a reduction in water or stream quality through stream sedimentation, and a resultant decrease in the fisheries resource (Utzig, 1978). Interpretations for surface erosion indicate which soils have the greatest potential for erosion, and thus where more planning or investment may be necessary to limit soil erosion accompanying land use activities.

Surface erosion hazard is made up of four factors: (1) climatic factors such as the intensity and frequency of rainfall; (2) vegetation factors such as the amount and kind of cover on the soil; (3) soil factors affecting inherent erodibility; and (4) topographic factors such as steepness and slope length.

Climate is not part of the soil as such, and there are few known treatments which can modify its influence. The amounts and kinds of vegetation cover, the second factor, are indirectly related to the soil. Vegetation reduces raindrop impact and rainfall intensity on the ground through interception processes, thereby reducing the runoff velocity and erosive power of water. This factor is relatively easy to manipulate, for example by logging, burning or seeding, and is thus better considered separately from inherent soil erosion hazard. The last two factors involve the soil itself and will be discussed in more detail.

One of the more obvious qualities of soils is their varying abilities to resist erosion. One soil may erode severely, while an adjacent soil may suffer little damage from the same kind of treatment. Olson and Wischmeier (1963) have shown that soil losses may vary 30-fold just due to basic soil

differences (when slope, rainfall, and management are identical). Anderson (1954) found that differences in natural sediment production associated with differences in soil erodibility vary by a factor as high as 75 in upland areas of California.

Most of the inherent erosion resistance in a soil seems to be related to two factors. The first factor is the stability of the surface soil aggregates and the second is how the soil accomodates water once it has passed the air-surface interface.

If the surface soil aggregates are relatively stable, they will resist dispersion by raindrop impact and resultant sealing of the pores in the soil surface. Water is then more likely to pass into the soil rather than over it. The two main soil properties affecting the stability of surface aggregates are litter thickness, soil texture and organic matter content. Litter provides a protective cover over the mineral soil which reduces raindrop impact.

The resistance of soil particles to detachment varies with their size and cohesive properties. Generally speaking, soils high in silt and low in clay are most erodible (Wischmeier and Mannering, 1969). Soils with moderate amounts of clay and organic matter develop secondary aggregates made up of finer particles (i.e. soil structure), which resist detachment in the manner of coarser particles. Silt-sized particles are most prone to erosion due to their small size and low cohesion. Very fine sand particles behave more like silt than other sand particles. Clay adds cohesiveness, while sands lack cohesion.

The way soil accomodates water once it has passed the air-surface interface is influenced by soil permeability, depth to impermeable layer, and drainage. If soil is permeable and permits a reasonably rapid infiltration and downward percolation of water, the excess moisture during and after rainfall will pass through the soil rather than over it. This action minimizes potential erosion by surface flow (run-off). Any restriction or

impedence to downward passage of water through the soil, such as massive bedrock, compacted layers, hardpans, or increases in clay content, can increase surface flow and erosion potential. Soils which are partially or fully saturated with water already due to drainage characteristics, can accept little additional moisture due to rainfall. This condition will result in increases in surface flow.

Other factors being equal, erosion is least on flat or slightly sloping land, and greatest on steep slopes. The effect of slope on erosion is directly related to its effect on the velocity of running water. As slope increases, the velocity and force which water can exert increases. It has been estimated that water velocity is about doubled when slope (expressed as a percentage) is quadrupled, and that doubling the velocity of water increases its erosive or cutting capacity four times and increases the size of particle it can roll or push along 64 times (Toogood and Newton, 1955). Meeuwig (1971) has estimated that erosion rates double for each 10% increase in slope where vegetation and litter cover of the soil is less than 50%.

Slope gradient is considered in the erosion risk interpretations (Table 3.8). Slope length is not considered as it is generally not a factor which can be described for various soils in a survey area. Rather, it is a consideration which can be assessed for particular sites. Slope length is nevertheless an important factor. Rothwell (1971) cited that doubling the horizontal length of a slope can increase erosion three times. Wischmeier and Smith (1978) provide an equation synthesizing the combined affects of slope steepness and length on soil erosion potential. For a given slope gradient, doubling slope length generally increases erosion potential 50% or 1.5 times.

Soils should be managed with their inherent erosive characteristics in mind, and the level of management adjusted accordingly (Haupt and Kidd 1965). Soils with high erosion potentials should be used with the greatest of care. Reinhart et al. (1963) show the value of careful planning in this regard. In a clearcut watershed with unplanned skidroads and no provisions

TABLE 3.8

EROSION RISK OF SOIL MATERIALS

Soil Material and Type	% Silt + Very Fine Sand	% Sand	% OM	1st Approx. of K	Soil Structure	Permeability	Soil Erodibility K Factor	% Coarse Fragments	Slope	Erosion Risk
Lacustrine (L0 to L3)	80%	10%	1%	.55	fine	Slow to Moderate	.55	<5%	<2% 2-5% >5%	Low Mod. High
Morainal (M1 to M6)	40%	40%	1%	.25	fine	Slow to moderate	.28	30-40%	0-9% 9-30% >30%	Low Mod. High
Colluvial (C0 to C6)	30%	50%	1%	.18	fine	moderate	.17	40-60%	0-45% 45-70% >70%	Low Mod. High
Fluvial (F1 to F5)	20%	70%	1%	.15	fine	moderate to rapid	.13	0-70%	0-45% 45-70% >70%	Low Mod. High

Note: 1. Soil properties listed on the table represent estimated average conditions based on field observations and laboratory data.
2. Soil-erodibility (K factor) determined using Wischmeier et al. (1971) soil-erodibility nomograph.
3. Erosion risk rating was then determined by comparing soil-erodibility factor with various slopes and coarse fragment contents using Coen and Holland (1976).

for road drainage, water turbidity was 56 000 ppm. In contrast, water turbidity for the intensive selection-cut with planned skidroads was 25 ppm, slightly higher than on an uncut (control) watershed where water turbidity was 15 ppm. Dryness (1966) summarizes many forest management-related causes of accelerated erosion.

Prescribed burning is a form of wildlife habitat manipulation whose chief aim is to improve forage quantity and quality. The main advantages of burning are (1) reduction of undesirable species, (2) provision of a suitable seed bed for desirable species, (3) to release nutrients for improved forage quality, (4) encouragement of resprouting, (5) reduction of shrubs to a suitable height for ungulate foraging, and (6) reduction of dangerous fuel accumulations. A major disadvantage of burning is soil erosion losses due to removal of protective vegetation.*

Although soil erosion potential ratings are provided for each soil type, these ratings are not predictions of actual erosion damage, but merely indicate the relative susceptibility of soils to erosion problems. Whether a soil may erode significantly or not must be assessed in relation to management activities. Burning which removes protective vegetation has often been considered an initiator of soil erosion, especially on steep slopes.

Packer and Williams (1976) investigated the effects of burning on soil stability in western Montana. None of the unlogged-unburned (control) plots produced any soil erosion due to overland flow from snowmelt. This lack of soil erosion, even though overland flow occurred, attests to the protective influence of vegetative cover on the unburned plots. Soil erosion from logged-burned plots averaged 63 kg/ha the first year, jumped to 188 kg/ha the second year, dropped to 18 kg/ha for the third and fourth years, and was essentially zero by the seventh year. Summer storms produced the most amount of erosion since they provided a much more efficient eroding force than snowmelt because of higher rates of overland flow and splash erosion from raindrop impact.

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*van Ryswyk (per. comm.) notes that another disadvantage of burning is possible severe damage to bunchgrass if burning is done when soil is dry.

Packer and Williams (1976) concluded that for most moderate slopes in their study area, burning was not significantly damaging since erosion losses were a relatively small and temporary impact following burning. However, they stressed that south-facing aspects, especially on steep slopes, could experience significant soil erosion losses. Being the driest, south aspects suffered the most intensive burns, experienced the most adverse impacts on soil and vegetative characteristics as a result of burning, and showed less improvement of these characteristics during the seven years following burning. They believed that the south aspects still remained in a more delicate runoff and erosional balance than other aspects.

According to van Ryswyk (per. comm.), overgrazed Chernozems on steep slopes would also be more susceptible to erosion than those in good condition. Slope and aspect could be involved on grasslands also. A Black soil with dense vegetation on a steep north aspect should be less erodible than an adjacent Dark Brown soil on a south aspect. An exception might be where the better moisture accumulation on the steep Black soil allowed for enough soil saturation to create land slides.

Schmautz (1970) noted that no sigificant damage to soils and watersheds was observed subsequent to controlled spring burns in northern Idaho, even on slopes as steep as 40 to 50 percent. Shrub species present apparently sprouted quickly and the slopes were revegetated in a few weeks. Logging and burning are likely to disturb existing soil and vegetation characteristics more than burning by itself, which may have accounted, in part, for the apparent greater soil losses in Packer and Williams' (1976) study than by Schmautz (1970). Schmautz (1970) concluded that soil erodibility is important to consider, but does not preclude the use of fire. Instead, areas with a high soil erosion potential will dictate that greater care in both planning and burning is needed.

3.7.3 SOIL IMPLICATIONS FOR WILDLIFE MANAGEMENT

Land units having similar soils tend to be similar in their capability to support wildlife, despite changes in vegetative conditions that have been brought about through various natural and human influences. The ability of similar soils to provide wildlife habitat can be exploited through appropriate vegetation manipulation. Some general soil characteristics affecting habitat for wildlife are discussed below.

Soil fertility has been relatively rated for each soil in Table 3.9 on the basis of naturally occurring nitrogen. The major nutrient deficiency for plant growth in the soils of the study area (aside from water) appears to be nitrogen. Other properties affecting soil fertility, such as cation exchange capacity, exchangeable bases, and base saturation are generally adequate.

Williams et al. (1979) concluded that nitrogen deficiencies on Orthic Black soils in nearby areas limits supply of nutrients and productivity to levels lower than the climate is capable of sustaining. Van Ryswyk et al. (1977) concluded that N-fertilization can increase growth two to four times for crested wheat grass; N-fertilization also tends to increase water-use efficiency. Freyman and Van Rywswyk (1969) note that sulphur can become deficient with N-fertilization for a study on pine grass response.

Under natural conditions, low organic matter content of soils usually also mean relatively low levels of nitrogen are in the soil. Agriculture Canada (1971) concluded that 95-98% of soil nitrogen on rangelands is in organic carbon form.

The range of % N in the soil for various horizons sampled in the study area are:

LFH:	0.6 - 1.0% N	High
black Ah:	0.2 - 0.3% N	Medium
brown Ah:	0.06 - 0.15% N	Low to very low
Bm:	0.05 - 0.11% N	Very low
BC, CK:	0.01 - 0.03% N	Trace

The high to trace ratings follow a general breakdown provided by Sprout and Kelley (1963) where High = >0.4% N, Medium = 0.25-0.4, Low = 0.1 - 0.25, Very Low = 0.02 - 0.1, and Trace = <0.02% N.

The ratings shown on Table 3.9 represent averages for the upper 20 cm of the soil (including LFH horizons) where most rooting occurs. Horizon

TABLE 3.9
SOIL IMPLICATIONS FOR WILDLIFE

Soil Type	Soil Fertility[1] (Nitrogen Content)	Biomass[2] Productivity	Erosion[3] Risk
M1	VL	VL	M
M2	L-VL	VL	M
M3	L	L	M
M4	L	L	M
M5	L-M	M	M
M6	M-L	M	M
C0	T	N	M-H
C1	VL	VL	M-H
C2	VL-L	VL	M-H
C3	L	L	M-H
C4	L	L	M-H
C5	L-M	L-M	M-H
C6	M-L	L	M-H
F0	L	L	L
F1	VL	VL	L
F2	L-VL	VL	L
F3	L	L	L
F4	L	L	L
V5	L-M	M-L	L
L0	T	N	M
L1	VL	VL	H-M
L2	L-VL	VL	H-M
L3	L	L	H-M
0	H	L	L

TABLE 3.9 (continued)

1 Soil Fertility (Nitrogen Content)

This column assesses average % N in the upper 20 cm of the soil, where:

T	Trace	<0.02%
VL	Very Low	0.02 - 0.1%
L	Low	0.1 - 0.25%
M	Medium	0.25 - 0.40%
H	High	>0.4%

2 Biomass Productivity

This column assumes forest capability is a reasonable indicator of the potential biomass productivity of each soil, as follows:

H	High	CLI Forest Capability 1-2
M	Moderate	CLI Forest Capability 3-4
L	Low	CLI Forest Capability 5-6
VL	Very Low	CLI Forest Capability 7
N	Nil	Essentially un-vegetated areas

Orthic Black soils were rated low.

3 Erosion Risk

This column summarizes the erosion risk of each soil from Table 3.8. For morainal soils, assumes slopes dominantly 9-30%; gentler slopes will have a low risk rating, while steeper slopes will have a high risk.

For colluvial soils, moderate risk applies to 45-70% slopes, and high risk applies to >70% slopes.

For fluvial soils, assumes slopes less than 45%. Steep escarpments of some fluvial terraces have a moderate to high erosion risk.

For lacustrine soils, 2-5% slopes have a moderate erosion risk, and >5% slopes have a high risk. LO soils occur on 2-5% slopes and are thus rated moderate.

depths per soil subgroup were averaged based on field samples as follows: Chernozems (LFH = 1 cm, Ah = 14 cm), Orthic Eutric Brunisol (LFH = 3 cm, Ah = 5 cm), Brunisolic Gray Luvisol (LFH = 4 cm, Ah = 2 cm), and Podzolic Gray Luvisol (LFH = 5 cm, Ah = 0 cm). For the remaining depths, Bm values were used.

In the upper 20 cm of soil, where most rooting occurs, the relative amounts of N are least at drier, lower elevations where conditions of low organic matter content exist in the soil. Most of the N in grassland soils is stored in the Ah mineral horizon, while most N in forest soils of this area occurs in the litter (LFH horizons).

In general, most soils in the study area, with the exception of Orthic Black soils and some forest soils with thick LFH horizons, have low to very low levels of N suggesting N fertilization would be beneficial. The seeding of nitrogen-fixing leguminous species or shrubs like Ceanothus might also improve N levels in the soils.

Agriculture Canada (1971) concluded that N fertilization yields in rangelands were greater for Black soils than for drier Brown soils, and that increases in yields improved where good forage species (e.g. bluebunch wheat grass and rough fescue) were in vigorous condition. They also noted that a 10 year improvement from a single N application could be found on an excellent condition wheat grass site. Summarizing results in Alberta, they noted no difference between late fall versus early spring applications, but did note that soil moisture conditions in fall and June precipitation does affect success of application.

Freyman and van Ryswyk (1969) conclude that N fertilization not only increases yields when applied to pine grass, but also palatability and nutritive value. They found that soils supporting Douglas-fir - pine grass communities to be particularly low in N. Of interest to wildlife managers and foresters is their finding that 14% of the N applied to these sites were absorbed by pine grass and that 17.5% where absorbed by herbs and presumably the rest by shrubs and trees or lost through the soil. Thus, a

large percentage of the N applied to these sites is being utilized by shrubs to improve browse conditions and by trees to improve their productivity. There was also a significant yield response to sulfur when applied with N.

In this regard, it should be pointed out that several different land users can conceivably benefit from N-fertilization, particularly in forested rangelands. Thus the costs of fertilizations should not necessarily be borne by one interest alone; similarly, economic assessment on benefit-costs of fertilization should take into account the benefits accrued by all. Fight and Dutrow (1981) indicate that N-fertilization is financially justifiable for timber production alone on many Douglas-fir sites in the Pacific Northwest.

Eastman and Bandy (1971) applied N in order to improve some bighorn sheep winter ranges in East Kootenay. Yields over four years increased by 99 to 150% depending on the amounts of N applied. They found no significant improvements in yield by applying other fertilizers with nitrogen.

According to Duncan and Hylton (1970), nitrogen fertilization in most areas has resulted in increased crude protein, increased succulence, and increased leaf-to-stem ratios. Even in semiarid areas, nitrogen fertilization has improved forage quality, although forage yields in these areas may not have been increased.

Carpenter and Williams (1972) provide an excellent review of the role of mineral fertilizers in big-game range improvement. Their review resulted in the following observations: nitrogen fertilization can increase biomass growth of shrub seedlings and increase production of shrubs; non-vigorous plants on relatively infertile sites appear to respond best; nitrogen and phosphorus fertilization tends to improve shrub growth over grasses; different plants respond differently to fertilization, therefore experimentation is necessary; forage yields increase for around five years subsequent to fertilizer application, although benefits decline rapidly each year; seral species generally respond better to fertilization than do more shade tolerant or climax species; fall and spring applications appear to provide

better results than summer applications; and improved protein content of forage as a result of fertilization increases palatability of forbs for wildlife.

Experiments by Brown and Mandery (1962) have revealed the management potential of fertilization both to attract deer away from forest plantations and to improve palatability of other forage for deer.

Biomass productivity is an important feature of soils that affects the production of forage plants, vegetation management methods and the feasibility of managing vegetative cover for various needs of wildlife. Ratings of forest capability are assumed to be a reasonably accurate indicator of the total biological productivity of an ecosystem or a soil type. Five arbitrary ratings are used in this report: high for forest capability classes 1-2, moderate for classes 3-4, low for classes 5-6, very low for class 7 and nil for soils with virtually no vegetative growth or bedrock outcrops. These ratings are given in Table 3.9 for each soil type.

The ratings are primarily based on the land capability for forestry classes given by Young and Fenger (in progress) for their soil associations that have been correlated with the soil types used in this study (see Appendix). The ratings they've provided compared favourably with productivity data reported by Steele et al. (1981) and Pfister et al. (1977) on similar habitat types in Idaho and western Montana. Comparisons with the productivity ratings given by Mitchell et al. (1981) for ecosystem associations also tend to support the forest capability ratings assumed on Table 3.9. Ecosystem associations which are given a medium site class rating usually correlate with comparable soils having a moderate forest capability rating. Similarly, their poor and low site classes tend to be rated as low, and their non-commercial sites as very low.

Van Ryswyk et al (1979) reported that growth of grasses on Orthic Black soils was 2 to 4 times that on Orthic Dark Brown soils. Presumably it

would be greater still relative to Orthic Brown soils. For this reason, Orthic Black soils (M3, C3, F3 and L3) were given a low productivity rating instead of very low even though they were rated Class 7 for forest capability.

Although soil fertility is an important factor governing biomass productivity, climatic conditions such as aridity and short growing season are particularly important factors affecting vegetative growth. In general, soils with a high biomass productivity rating have the potential to grow a greater amount of forage for wildlife. But, soils with higher biomass productivity ratings produce a more rapid rate of plant succession, and may be best adapted for production of cover compared to those with lower ratings, since the former would require more frequent treatment in order to supply seral forage. Also, the higher productivity ratings occur in higher elevations (since climatic aridity is less) where snow depth limitations for wintering ungulates potentially becomes limiting and provision of adequate cover more important.

Soil erosion potential ratings are given in column 4 on the table for each soil type; the ratings are described in the previous section. Whenever a dual rating is given, for example moderate to high, the areas with higher erosion potential are invariably on the steeper slopes.

Soil erosion potential is an important consideration whenever managers contemplate removing protective vegetative cover. Prescribed burning, for example, may result in significant erosion on soils with a high erosion potential. Whenever erosion occurs, loss of soil nutrients results and soil productivity declines. Although soil erosion may occasionally result in short-term benefits, for example the establishment of pioneer seral vegetation communities with abundant forage, long-term implications are generally negative. Resource management options for deteriorating soils become more restrictive and forage species may become less nutritious.

Soil erosion potential ratings are not predictions of damage, but only subjective assessments of the relative susceptibility of soils to erosion. Soils with high erosion potential should be monitored carefully if management activites such as burning are prescribed. In this way, the response of similar soils in other areas can be better predicted.

CHAPTER FOUR
VEGETATION

4.1 INTRODUCTION

To assess the vegetation the framework of Biophysical Vegetation Zonation and Vegetation Landscapes was used. This framework is compared to previous studies of similar areas in British Columbia and the northwest United States in Appendix C.2.

Throughout the report vascular plant names follow the conventions of Taylor and MacBryde (1977). A list of species is presented in Appendix C.1.

4.1.1 VEGETATION ZONATION[1]

Vegetation Zonation is based on the potential distribution of dominant vegetation which is attributable to climatic factors. The Vegetation Zonation classification is composed of four levels:

1. Vegetation Region
2. Vegetation Section
3. Vegetation Zone
4. Vegetation Subzone

The Vegetation Zones and Subzones are the foundation of this classification from which the upper categories are derived.

Vegetation Zonation for the study area is described in Section 4.3.

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[1]For a description of the philosophy and definitions of this classification see van Barneveld (1976) and Walmsley and van Barneveld (1977).

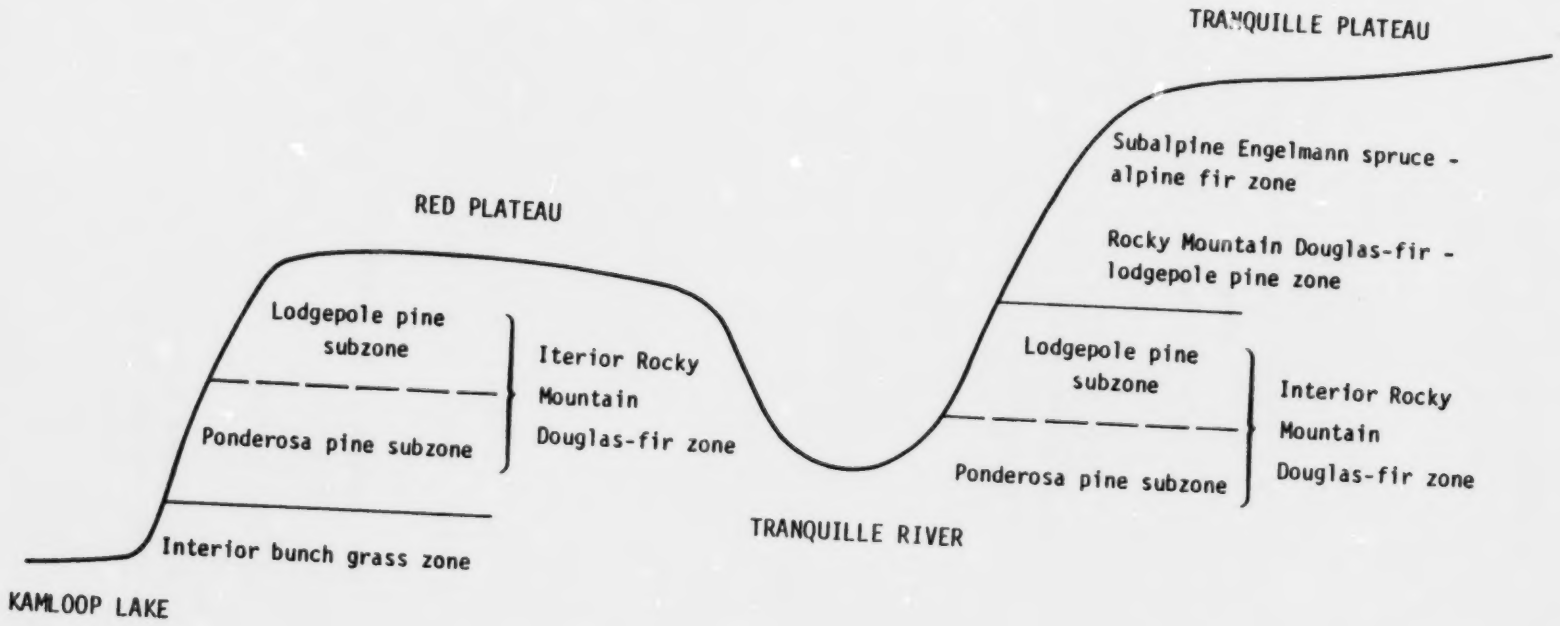

Figure 4.1 Schematic Diagram of Vegetation Zones and Subzones of the Study Area.

A Vegetation Region is characterized by a definitive pattern of Vegetation Zones, developed under direct influence of a broadly homogenous climate and topography. A Vegetation Section is a subdivision of a Region that displays different Vegetation Zonation patterns resulting from variations of the climate within the Vegetation Region. A Vegetation Zone is an area over which particular species become dominant (climax) if disturbance of the vegetation does not occur. A Vegetation Subzone, a subdivision of the Zone, is defined on the basis of climate - related successional trends of the dominant vegetation.

4.2 METHODS

In this study 75 vegetation and soils plots were selected, each chosen to be representative of a site of homogenous vegetation and uniformity in apparent soil and other physical characteristics. The data were recorded using a standard data form and sampling techniques as described in Walmsley et al. (1980). As well, 22 vegetation and soil plots, provided by the Research Branch, British Columbia Ministry of Forests, Kamloops, British Columbia, were used.

4.3 BROAD VEGETATIVE PATTERNS

The study area is found within the Dry Interior Region, Ashcroft Section. Within the study area three Vegetation Zones have been recognized. The Vegetation Zones include the Interior bunch grass zone at lower elevations, the Interior Rocky Mountain Douglas-fir zone at middle elevations and the Subalpine Engelmann spruce - alpine fir zone at upper elevations. These zones and their associated subzones are shown schematically in Figure 4.1. These zones as well as subzones and Vegetation Landscapes are mapped for the study area.

4.3.1 INTERIOR BUNCH GRASS ZONE

This zone is characterized by climax communities dominated by bluebunch wheat grass on average sites.

This is the lowest elevation zone of the study area. The zone generally occurs below 600 m (2000 ft.) except on south to southwest facing slopes or on sites with shallow soils, where the zone may extend to 750 m (2500 ft.). It occurs mainly in the Thompson River Valley above Kamloops Lake although a portion extends into the Tranquille River Valley.

Low moisture availability is the most significant factor determining vegetation patterns in this zone. This zone receives between approximately 120 and 150 mm in growing season precipitation (Blower et al., in preparation). Because of limited moisture, establishment of vegetation after disturbance is slow, and any changes in the vegetation are generally long-term and difficult to reverse. Moisture availability increases with elevation and biomass productivity is reflected in this.

Within the zone, on sites with medium textured materials and average moisture conditions, vegetation succession will lead to climax communities dominated by bluebunch wheat grass with lesser amounts of big sagebrush, Sandberg's blue grass, sagebrush mariposa lily and prairie sagebrush. Much of this zone has been affected by disturbance and presently has seral vegetation, dominated by big sagebrush, a sparse cover usually of bluebunch wheat grass, Sandberg's blue grass, needle-and-thread grass, low pussytoes, and prickly-pear cactus. Some severely disturbed areas are dominated by drooping brome grass (cheat grass).

The soils of this zone are classified as Brown Chernozems at lower elevations and Dark Brown Chernozems at upper elevations. These soils are characterized by organic accumulation in the upper soil horizons. Soil moisture is quite limiting within this zone.

On coarse-textured soils of gravels and sands, which have a low moisture holding capacity, and on knolls, the vegetation is dominated by needle-and-thread grass with lesser amounts of big sagebrush, Sandberg's blue grass and common rabbitbrush (Franklin and Dyrness, 1973; McLean, 1979; Parsons

et al., 1971). These areas have generally been subject to disturbance and are presently dominated by big sagebrush with lesser amounts of needle-and-thread grass, sand dropseed and prickly-pear cactus. On many of the fluvial terraces within the zone, bluebunch wheat grass appears to be the dominant climax species.

On steep slopes with coarse-textured talus material moisture is deficient at the soil surface due to rapid percolation but often it is available along the rock-soil interface and at the base of the slopes. Deeper rooting species such as common saskatoon and ponderosa pine are often present on such slopes while at the base, shrub garlands (Franklin and Dyrness, 1973) dominated by common saskatoon, choke cherry, roses and smooth sumac are common. Ponderosa pine may sometimes be present.

Larger gulleys or creek bottoms, such as the one near the mouth of Doherty Creek, are dominated by a lush shrub growth of Rocky Mountain maple, western birch, common snowberry, trembling aspen, red-osier dogwood and poison-ivy with a grass cover of blue grass, bluebunch wheat grass and needle-and-thread grass. Black cottonwood is present along the Tranquille River within this zone.

On shallow soils and rocky areas, which are common along the steep slopes leading down to Kamloops Lake, vegetation cover is sparse and may be composed of common rabbitbrush, big sagebrush, umbrellaplant, needle grass, blue grass and mosses and lichens.

4.3.2 INTERIOR ROCKY MOUNTAIN DOUGLAS-FIR ZONE

This zone is characterized by climax communities of Rocky Mountain Douglas-fir on average sites.

This is the middle elevation zone of the study area. It generally occurs between 600 m (2000 ft.) and 1200 m (4000 ft.). On areas of south to southwest facing slopes the zone may occur from 750 m (2500 ft.) to 1500 m (5000 ft.).

It occurs in the Thompson River Valley above Kamloops Lake, on the Red Plateau and in the Tranquille River Valley and the Watching Creek area.

Moisture availability, temperature and evapotranspiration differences with elevation and aspect determine the vegetation patterns within this zone. Generally there is an increase in available moisture and a decrease in temperatures with increasing elevation.

At lower elevations of this zone seral communities of ponderosa pine, big sagebrush and bluebunch wheat grass lead to climax communities of Rocky Mountain Douglas-fir and bluebunch wheat grass. At intermediate elevations seral communities of ponderosa pine, common saskatoon and bluebunch wheat grass lead to climax communities of Rocky Mountain Douglas-fir and pine grass. At upper elevations of this zone seral communities of lodgepole pine, soopolallie and pine grass lead to climax communities of Rocky Mountain Douglas-fir and pine grass. Variations of plant communities in the landscape are discussed by subzone.

Within the Interior Rocky Mountain Douglas-fir zone two subzones are recognized: the Ponderosa pine subzone and the Lodgepole pine subzone.

Ponderosa Pine Subzone

This subzone is characterized by successional communities dominated by ponderosa pine, leading to climax communities dominated by Rocky Mountain Douglas-fir.

This subzone occurs between 600 m (2000 ft.) and 1050 m (3500 ft.) although on south to southwest facing slopes it may occur from 750 m (2500 ft.) to 1350 m (4500 ft.). It occurs above the Interior bunch grass zone in the Kamloops Lake area and into the Tranquille River Valley only on south facing slopes.

The soils within this subzone vary from seral shrub-grassland areas to forested areas. Soils in the shrub-grassland areas are Dark Brown Chernozems at lower elevations and Black Chernozems at higher elevations. Within the forested areas soils are generally either Eutric Brunisols on medium to coarse textured materials or Gray Luvisols on finer textured materials. Soil moisture deficiency is common, and is extreme on south to southwest facing slopes, areas with shallow soils, steep slopes or areas with shrub-grassland vegetation. Shading by trees prevents excessive evapotranspiration from the soil and ground vegetation.

On sites with deep, medium-textured soils at lower elevations of this subzone, successional communities generally develop from a grassland community dominated by bluebunch wheat grass with lesser amounts of big sagebrush, to an open forested community dominated by ponderosa pine and bluebunch wheat grass and then to a climax community dominated by Rocky Mountain Douglas-fir and bluebunch wheat grass, often with lesser amounts of rough fescue. Intensive grazing on these sites, particularly at younger successional stages, creates a similar vegetation to that which is presently found in the Interior bunch grass zone, with communities dominated by big sagebrush, needle-and-thread grass, Sandberg's blue grass, prairie sagebrush and prickly-pear cactus. These communities may be quite persistent with slow reestablishment of bluebunch wheat grass and ponderosa pine. However, big sagebrush provides shade which may allow ponderosa pine to establish. For the first three months of their life ponderosa pine seedlings are susceptible to heat injury of the stem and require some shade for this period (Brayshaw, 1965). Tall grasses may provide a similar shade cover.

On sites with deep, medium textured soils at the upper elevations of this subzone, successional communities generally develop through forested communities dominated by ponderosa pine, Rocky Mountain Douglas-fir, common saskatoon and bluebunch wheat grass to a climax community dominated by Rocky Mountain Douglas-fir and pine grass. Rough fescue may be abundant through all stages on these sites.

On areas with shallow soil (less than 1 metre), moisture availability is low and the vegetation generally goes from early successional communities of common rabbitbrush, common saskatoon, bluebunch wheat grass and prairie koeleria, to open forests dominated by ponderosa pine, Rocky Mountain Douglas-fir, Rocky Mountain juniper, common rabbitbrush and bluebunch wheat grass, and then to open forests dominated by Rocky Mountain Douglas-fir, Rocky Mountain juniper and bluebunch wheat grass. The rate of succession on these sites is generally quite slow and establishment of tree seedlings is inhibited in early stages of succession. Commonly these sites are associated with south to southwest facing slopes in which severe soil moisture deficits are frequent during the summer.

On sites with coarse-textured talus materials, moisture is deficient at the soil surface due to rapid percolation. Moisture is available along the rock-soil interface and at the base of the slopes. Deeper rooting species such as common saskatoon, choke cherry, roses, common rabbitbrush, spreading dogbane and shrubby penstemon may be present.

On moister sites within this subzone, such as in receiving positions at the base of slopes, succession begins with lush communities dominated by abundant Rocky Mountain Douglas-fir regeneration with common saskatoon, Oregon-grape, roses, kinnikinnick, dense pine grass and sometimes snowbush ceanothus. This community leads to a dense forest dominated by dense Rocky Mountain Douglas-fir and a sparse understory of birch-leaved spirea and pine grass. These sites have a rapid rate of succession due to favourable moisture availability. Such vegetation occurs on the north side of Tranquille River south of Watching Creek, at the base of the slope.

On non-exposed aspects a similar climax vegetation may result although the vegetation is not as lush and the rate of succession is generally slower. Seral communities commonly are dominated by ponderosa pine, common saskatoon, roses, kinnikinnick and pine grass.

Small gulleys are common throughout this subzone where increased moisture affords a lusher plant growth generally having dense Rocky Mountain Douglas-fir regeneration or a dense cover of common saskatoon and Rocky Mountain maple.

Larger gulleys, often associated with small creeks, such as Doherty Creek have lush shrub growth of Rocky Mountain maple, roses, common snowberry, western birch, willow, trembling aspen and red-osier dogwood.

On the upper areas of Mara Hill and on similar sites on the east side of the study area succession often leads from grassland communities dominated by Kentucky blue grass, rough fescue, bluebunch wheat grass and prairie koeleria to a forested community dominated by ponderosa pine, rough fescue and bluebunch wheat grass and eventually to a climax community of Rocky Mountain Douglas-fir, pine grass and rough fescue.

On very steep, northeast facing slopes above Tranquille River, east of Watching Creek, rubbly colluvial material supports communities of sparse Rocky Mountain Douglas-fir with common saskatoon, arrow-leaved balsamroot and a dense cover of bluebunch wheat grass, with common selaginella covering rocks on the surface. Climax communities may be dominated by open stands of Rocky Mountain Douglas-fir, rough fescue and pine grass. These sites have low moisture availability due to rapid runoff and percolation. The vegetation present is important in erosion prevention.

Lodgepole Pine Subzone

This subzone is characterized by successional communities dominated by lodgepole pine leading to climax communities dominated by Rocky Mountain Douglas-fir. This subzone occurs between 1050 m (3500 ft.) and 1200 m (4000 ft.), although on south to southwest facing slopes this subzone occurs from 1350 m (4500 ft.) to 1500 m (5000 ft.).

The soils within this subzone are generally classified as Brunisolic Gray Luvisols on morainal material. These soils have a distinct clay enriched horizon which may hold soil moisture in the rooting zone. On coarser textured materials Dystric or Eutric Brunisols occur. Soil moisture availability is better in this subzone than the Ponderosa pine subzone although moderate soil moisture deficits are common in the summer.

Sites with deep, medium textured soils predominate in this subzone. On these sites succession generally proceeds through early stages with fireweed and pine grass to seral forested communities dominated by lodgepole pine, soopolallie, roses and pine grass and then to climax communities dominated by Rocky Mountain Douglas-fir and pine grass. These areas are subjected to moderate moisture deficits in the summer.

On dry, south to southwest facing slopes, particularly in the Tranquille River valley, plant succession proceeds from early stages dominated by Rocky Mountain Douglas-fir regeneration, common saskatoon, soopolallie and bluebunch wheat grass, to forested communities of Rocky Mountain Douglas-fir, soopolallie, bluebunch wheat grass and pine grass, and eventually to a climax stand dominated by Rocky Mountain Douglas-fir and pine grass. Sites that support this kind of vegetation are subject to relatively severe moisture deficits for this subzone, due to intense solar radiation. These sites have a relatively slow rate of succession.

On moist, steep, north to northeast facing slopes, which are common along the Tranquille River valley, vegetation succession proceeds from early vegetation of Rocky Mountain maple, pine grass, fireweed, common moss and layered moss to a generally dense forest of Rocky Mountain Douglas-fir, a sparse cover of Rocky Mountain maple and pine grass, and a continuous moss cover composed of common moss, layered moss and feather moss. These sites have favourable moisture availability.

In the Watching Creek area trembling aspen commonly forms seral stands. Trembling aspen often grows after repeated or intense fires that eliminate lodgepole pine seeds. Trembling aspen occurs on both dry and moist sites of soils of moderate to good base saturation.

On the drier sites, vegetation is dominated by aspen stands with an understory of soopolallie, roses, pine grass and heart-leaved arnica. This will lead to a climax community dominated by Rocky Mountain Douglas-fir and pine grass. The understory vegetation is very similar to that of lodgepole pine forests, however, the understory of aspen stands has much greater annual production of biomass (Tisdale and McLean, 1957). Since aspen has the ability to sucker, logging or burning could set succession back to an early stage dominated by young trembling aspen.

Moister sites with trembling aspen are dominated by an understory of soopolallie, common snowberry, pine grass and cream-coloured peavine. These sites are succeeding to climax forests dominated by white spruce, common snowberry and pine grass. These sites are in moist, receiving slope positions and may be subjected to cold air drainage.

White spruce may form climax stands in various other locations within this subzone including areas receiving moisture from upslope (similar to the aspen stands previously discussed), areas subject to cool air pooling and floodplain areas. Areas with white spruce climax in receiving positions with cool air pooling are present on the Red Plateau and near the Pass Lake area. These areas generally proceed from early seral vegetation dominated by fireweed, pine grass and dwarf blueberry, succeeding to seral forests dominated by lodgepole pine, soopolallie, pine grass, dwarf blueberry and Canadian bunchberry. This vegetation leads to a climax of white spruce, pine grass, dwarf blueberry and common moss.

Within this subzone floodplain areas of significant size are common on the Tranquille River and Watching Creek. These areas generally support early seral

vegetation dominated by red-osier dogwood, paper birch, alder and horsetails and succeed to seral forests dominated by black cottonwood, paper birch, red-osier dogwood, alder, wild sarsaparilla and horsetails. These sites generally succeed to climax stands dominated by white spruce, red-osier dogwood and horsetails, although black cottonwood may remain as a component if flooding occurs relatively frequently. Sites with this kind of vegetation generally have favourable moisture availability from flooding, high water tables and from being in receiving slope positions as well as having relatively low evapotranspiration due to cool air pooling.

Gulleys, which have increased moisture availability, sometimes with small creeks, are fairly common within this subzone. These areas generally have dense tree regeneration and may have Rocky Mountain maple, common saskatoon, common snowberry, western birch, roses, willows, red-osier dogwood, alder and showy aster.

On the gently sloping terrace east of Watching Creek just above Tranquille River at approximately 1100 m (3600 ft.) is a moist, receiving area dominated by paper birch and Rocky Mountain Douglas-fir with a lush shrub and herb understory intermixed with stands dominated by lodgepole pine, soopolallie and pine grass. The lush understory of these paper birch sites is generally dominated by western thimbleberry, roses, common snowberry, soopolallie, Oregon-grape, red-osier dogwood, pine grass and cream-coloured peavine. Within the study area this kind of vegetation is unique to these sites. These areas appear to be rich in moisture and nutrients from seepage. Sites bordering small steams running through this area may have a dense cover of red-osier dogwood.

4.3.3 SUBALPINE ENGELMANN SPRUCE-ALPINE FIR ZONE

This zone is characterized by climax communities dominated by Engelmann spruce and alpine fir on average sites. Spruce hybrids (white X Engelmann) may dominate climax stands at lower elevations along with alpine fir. This is

In the Watching Creek area trembling aspen commonly forms seral stands. Trembling aspen often grows after repeated or intense fires that eliminate lodgepole pine seeds. Trembling aspen occurs on both dry and moist sites of soils of moderate to good base saturation.

On the drier sites, vegetation is dominated by aspen stands with an understory of soopolallie, roses, pine grass and heart-leaved arnica. This will lead to a climax community dominated by Rocky Mountain Douglas-fir and pine grass. The understory vegetation is very similar to that of lodgepole pine forests, however, the understory of aspen stands has much greater annual production of biomass (Tisdale and McLean, 1957). Since aspen has the ability to sucker, logging or burning could set succession back to an early stage dominated by young trembling aspen.

Moister sites with trembling aspen are dominated by an understory of soopolallie, common snowberry, pine grass and cream-coloured peavine. These sites are succeeding to climax forests dominated by white spruce, common snowberry and pine grass. These sites are in moist, receiving slope positions and may be subjected to cold air drainage.

White spruce may form climax stands in various other locations within this subzone including areas receiving moisture from upslope (similar to the aspen stands previously discussed), areas subject to cool air pooling and floodplain areas. Areas with white spruce climax in receiving positions with cool air pooling are present on the Red Plateau and near the Pass Lake area. These areas generally proceed from early seral vegetation dominated by fireweed, pine grass and dwarf blueberry, succeeding to seral forests dominated by lodgepole pine, soopolallie, pine grass, dwarf blueberry and Canadian bunchberry. This vegetation leads to a climax of white spruce, pine grass, dwarf blueberry and common moss.

Within this subzone floodplain areas of significant size are common on the Tranquille River and Watching Creek. These areas generally support early seral

vegetation dominated by red-osier dogwood, paper birch, alder and horsetails and succeed to seral forests dominated by black cottonwood, paper birch, red-osier dogwood, alder, wild sarsaparilla and horsetails. These sites generally succeed to climax stands dominated by white spruce, red-osier dogwood and horsetails, although black cottonwood may remain as a component if flooding occurs relatively frequently. Sites with this kind of vegetation generally have favourable moisture availability from flooding, high water tables and from being in receiving slope positions as well as having relatively low evapotranspiration due to cool air pooling.

Gulleys, which have increased moisture availability, sometimes with small creeks, are fairly common within this subzone. These areas generally have dense tree regeneration and may have Rocky Mountain maple, common saskatoon, common snowberry, western birch, roses, willows, red-osier dogwood, alder and showy aster.

On the gently sloping terrace east of Watching Creek just above Tranquille River at approximately 1100 m (3600 ft.) is a moist, receiving area dominated by paper birch and Rocky Mountain Douglas-fir with a lush shrub and herb understory intermixed with stands dominated by lodgepole pine, soopolallie and pine grass. The lush understory of these paper birch sites is generally dominated by western thimbleberry, roses, common snowberry, soopolallie, Oregon-grape, red-osier dogwood, pine grass and cream-coloured peavine. Within the study area this kind of vegetation is unique to these sites. These areas appear to be rich in moisture and nutrients from seepage. Sites bordering small steams running through this area may have a dense cover of red-osier dogwood.

4.3.3 SUBALPINE ENGELMANN SPRUCE-ALPINE FIR ZONE

This zone is characterized by climax communities dominated by Engelmann spruce and alpine fir on average sites. Spruce hybrids (white X Engelmann) may dominate climax stands at lower elevations along with alpine fir. This is

the uppermost zone of the study area. The zone generally occurs above 1200 m (4000 ft.) except on south to southwest facing slopes where it generally occurs above 1500 m (5000 ft.). The zone occurs in the Tranquille Plateau area. The topography is of a gently rolling nature mainly covered by coniferous forests with fens, dominated by sedges and glandular birch, common in depressional areas. Generally this is the coolest and wettest zone in the study area with the shortest growing season and frost-free period. Dominant disturbances within this zone are fires and logging. Some grazing occurs.

Within the study area only the Rocky Mountain Douglas-fir - lodgepole pine subzone occurs.

Rocky Mountain Douglas-fir - Lodgepole Pine Subzone

This subzone is characterized by successional communities dominated by lodgepole pine with lesser amounts of Rocky Mountain Douglas-fir, particularly on southern exposures.

Generally, soils within this subzone are Humo-Ferric Podzols or Dystric Brunisols on medium to coarser textured materials and Podzolic Gray Luvisols on finer textured materials. The soils are relatively deeply leached due to high precipitation in these areas.

On sites with deep, medium textured soils, succession generally proceeds through early stages with fireweed, pine grass, northern twinflower, grouseberry and arctic lupine leading to seral forests dominated by lodgepole pine, grouseberry, pine grass, arctic lupine and common moss and then to climax stands dominated by Engelmann spruce, alpine fir, grouseberry and common moss. In moister areas, often with restricted drainage, thin-leaved mountain alder may be common after fire or logging and may remain in seral forests. In better drained areas, usually on luvisolic soils, Sitka alder, which is a nitrogen fixer, may be abundant. In some logged areas shrub species such as American red raspberry, western thimbleberry and Oregon boxwood may be common along with dense stands of fireweed.

On dry, south to southwest facing slopes seral communities are dominated by Rocky Mountain Douglas-fir, lodgepole pine, common juniper, pine grass and kinnikinnick. These sites are generally slow in succeeding to a climax community of Engelmann spruce, alpine fir, dwarf blueberry, northern twinflower and common moss.

In wetter areas within this subzone vegetation may be dominated by productive stands of alpine fir and Engelmann spruce with an understory of black swamp gooseberry, common horsetail, wood-rushes and mosses. Areas with this kind of vegetation are subject to a high water table, poor soil drainage, and poor soil aeration.

Wet, depressional areas are common on the Tranquille Plateau. These areas generally have poorly drained, organic soils with fen vegetation dominated by sedges, and glandular birch. Willows and glandular birch are frequently common near the margins of the fens.

4.4 VEGETATION LANDSCAPES AND MANAGEMENT CONSIDERATIONS

Vegetation Landscapes represent landscape areas that are relatively homogenous with regard to soils, surficial materials, climate and successional trends of vegetation. Each kind of vegetation landscape represents ecological segments that are relatively similar with regard to management alternatives and constraints to use. The Vegetation Landscapes represent a broad level of vegetation ecosystem and a fair amount of variation is expected within each unit.

The Vegetation Landscapes are presented by Vegetation Zone and Subzone. Information that applies to management throughout a zone or subzone is presented.

For the more common Vegetation Landscapes within the study area, tables showing successional trends, along with descriptions of the landscapes, are given. Succession will have different starting points and different pathways

depending on time of disturbance, intensity of disturbance and specific variations in climatic events. Prediction of precise development of vegetation is often not possible, however, general trends and processes can be identified. Knowledge of these trends is valuable in management of vegetation as they identify types of natural vegetative cover that can be grown on various parts of the landscape. Not all stages of the successional trends are based on actual samples but some are extrapolated from known samples, ecological theory and apparent trends, as well as from information from previous studies.

These theories should be tested and verified by monitoring sites where management takes place. Monitoring should consider short and long term changes both in the soil and vegetation, in particular, dealing with nutrient cycling and biomass productivity.

Interpretations of each Vegetation Landscape and it stages are presented in Blower et al. (in preparation). These interpretations are aimed at wildlife management.

Determinations of forage productivity and capability, fuel loads and possibly snow interception by trees and shrubs require further work.

A list of plant species, with nomenclature following Taylor and MacBryde (1977), is provided in Appendix C.1.

4.4.1 INTERIOR BUNCH GRASS ZONE

Grazing, fire and cultivation are the dominant factors determining the existing pattern of seral vegetation in this zone (Franklin and Dyrness, 1973). The vegetation of this zone has been greatly affected by intensive grazing use (Tisdale, 1947). Intensive grazing results primarily in a decrease of bluebunch wheat grass and other large perennials which are not adapted for concentrations of large herbivores (Mueggler and Stewart, 1980; Tisdale and Hironaka, 1981). In determining effects of grazing on plant species, their

other plants (Cranston, personal communication[1]). Unless biological controls prove effective in the future the Interior bunch grass zone is in danger of becoming dominated by knapweed (Cranston, personal communication[1]). Protection from knapweed encroachment is essential to maintain the forage base for wild ungulates in spring range (Cranston, 1980) as well as for livestock.

In grasslands, often the climax or near-climax community is the most productive community and in this zone it may take up to 50 years for the climax community to be restored after severe disturbance (McLean, 1979). The main plants to increase with protection are bluebunch wheat grass and rough fescue, while Sandberg's blue grass, low pussytoes and common rabbitbrush decrease (McLean and Tisdale, 1972).

Erosion of soil may be significant in this zone partly because of limited tree cover which would slow winds and subsequent wind erosion. A cover of big sagebrush helps to slow wind speeds at the soil surface. Grazing and fires can help to accelerate soil erosion because of the removal of protective cover. On steep slopes soil loss differences between grazed and ungrazed areas are quite significant (Johnson et al., 1980). Heavy grazing within this zone also leads to a lack of plant litter on the soil surface which exposes the soil to erosion.

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[1]Cranston, R. Personal Communication. British Columbia Ministry of Agriculture and Food, Kamloops, British Columbia. 1982.

pattern of growth must be understood. The main period of active growth, within this zone, is confined to April, May and early June. Plants eaten during later parts of this period have little opportunity to make further growth or store up needed root reserves (Tisdale, 1947). Heavy grazing results mainly in an increase in big sagebrush, as well as Sandberg's blue grass, prairie sagebrush, prickly-pear cactus, and needle-and-thread grass (initially). McLean and Tisdale (1972) recommend to graze these lands only during the season of least damage. Once big sagebrush has established dominance on these areas it is persistent and quite competitive, inhibiting reestablishment of grasses. Sagebrush has a two-storied root system that allows utilization of moisture at the soil surface as well as at greater depths (Sturges, 1978). This ability may allow sagebrush to persist in climax stands in small but significant amounts.

Where stands of big sagebrush are removed, elimination of competition has allowed grass a chance to regain its lost dominance, especially if protected from grazing for a few years (Brayshaw, 1965). Burning and spraying are the most economical methods for controlling sagebrush (Mueggler and Stewart, 1980). A doubling or even tripling of herbaceous production is not uncommon after control (Mueggler and Stewart, 1980). Fire on areas with big sagebrush in good range condition will decrease sagebrush and increase understory species, however the combination of fire and overgrazing reduces sagebrush, grasses and more palatable forbs which may cause these sites to be invaded by persistent species such as drooping brome grass (Tisdale and Hironaka, 1981). Where a good understory of perennial grasses and forbs does not exist sagebrush control is ineffective unless accompanied by planting of desirable species (Mueggler and Stewart, 1980), otherwise big sagebrush will seed back and regain its dominance.

A concern within this zone is the possible spread of diffuse and spotted knapweed. Knapweed spreads easily when there is little competition from native plants, although it is capable of spreading slowly, even in areas of good range condition, as it contains phytotoxic chemicals which inhibit the growth of

VEGETATION LANDSCAPES OF THE INTERIOR BUNCH GRASS ZONE

Western birch - Rocky Mountain maple vegetation landscape (BM)

The vegetation of this landscape is dominated by western birch, Rocky Mountain maple, trembling aspen, common snowberry, red-osier dogwood, Kentucky blue grass and needle-and-thread grass. This landscape is present in moisture receiving slope positions of deeply cut gulleys in the Interior bunch grass zone. Seasonal creeks may be associated with these gulleys. Early successional stages are dominated by a lush shrub cover, while the forested cover generally consist of a broad-leaved canopy. This landscape has limited areal extent in the study area.

Black cottonwood - red-osier dogwood vegetation landscape (CD)

The vegetation of this landscape leads from early stages of shrub dominated vegetation to edaphic climax, broad-leaved forests dominated by black cottonwood with a dense shrub layer of red-osier dogwood. This landscape is found on floodplain areas which generally have coarse-textured soils that are well-aerated. The soils are frequently Cumulic Regosols.

Needle-and-thread grass - big sagebrush vegetation landscape (NS) (see Figure 4.2)

The vegetation of this landscape generally succeeds from a grass-forb cover (NS2) to a grass dominated cover with forbs and shrubs (NS6). This landscape is generally found on well to rapidly drained soils with deep, coarse textured fluvial materials within the Interior bunch grass zone. This landscape may also be found on rapidly drained knolls with coarse textured

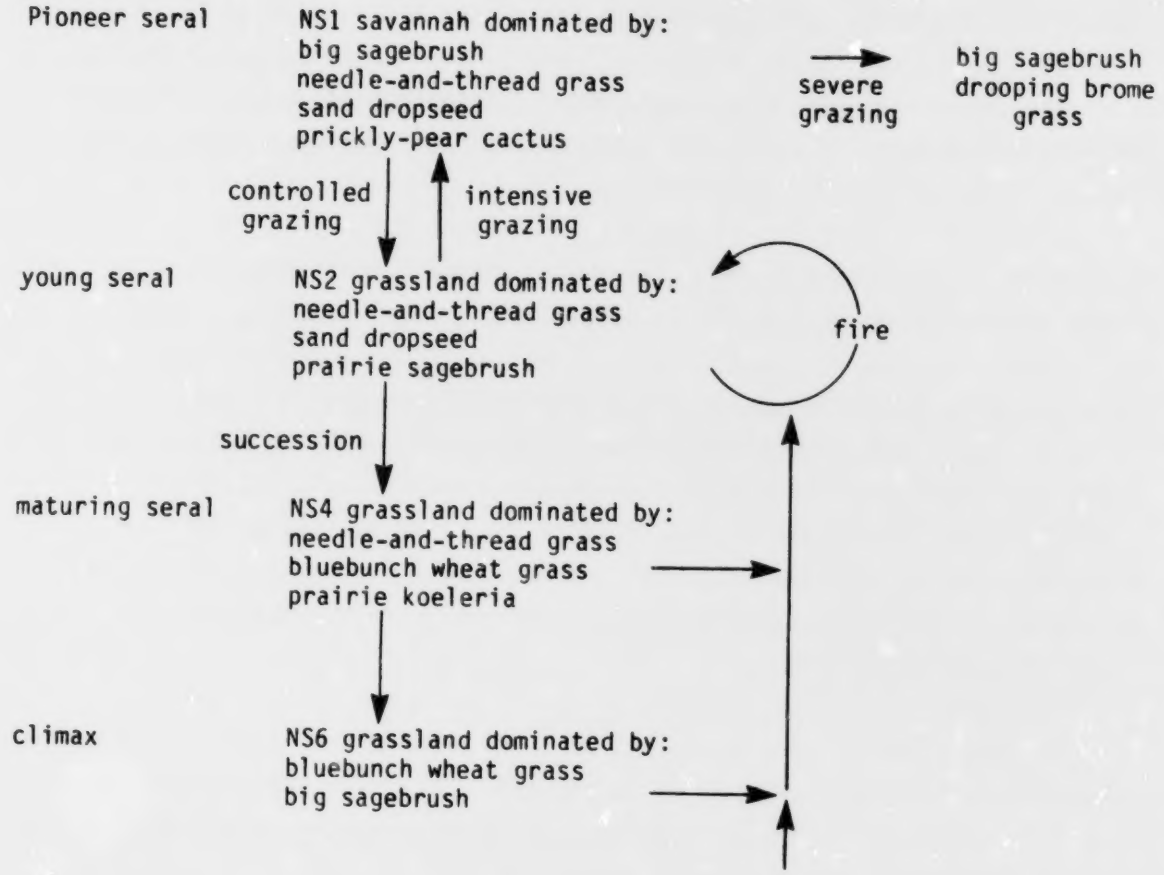

Figure 4.2 Successional trends of the Needle-and-thread grass - big sagebrush vegetation landscape (NS)

materials. These sites generally have rapid percolation of water which causes the soil to be droughty quite early in the growing season. Because of dry conditions vegetation establishment is restricted and succession is very slow.

The soils are generally Orthic Brown Chernozems at lower elevations and Orthic Dark Brown Chernozems at upper elevations of where this landsape is found. Nutrient levels are usually low.

After disturbance, the vegetation becomes dominated by persistent, competitive species such as big sagebrush.

A cover of big sagebrush (NS1) develops following prolonged grazing of these sites at any successional stage. Severe overgrazing results in sparse grass and forb cover, leaving the soil susceptible to erosion because of limited litter cover, little soil binding by roots and little interception of precipitation by vegetation. As well, organic material, which supplies nutrients and retains moisture in the rooting zone of these coarse textured soils, does not accumulate.

To return to a cover dominated by needle-and-thread grass and bluebunch wheat grass, grazing needs to be controlled. Fire will remove big sagebrush from these areas, however if a dense grass cover is not present after a fire, big sagebrush will reestablish by seed.

Ponderosa pine - Rocky Mountain juniper vegetation landscape (PJ)

The vegetation of the landscape succeeds from a grass cover of bluebunch wheat grass to an open cover of ponderosa pine, Rocky Mountain juniper and bluebunch wheat grass. This landscape is associated with small gulleys which provide favourable moisture conditions for tree establishments, throughout the Interior bunch grass zone.

Successional trends were not determined for this landscape.

Common rabbitbrush - bluebunch wheat grass vegetation landscape (RW)

The vegetation of this landscape generally succeeds from a sparse shrub-grass cover of common rabbitbrush, big sagebrush and bluebunch wheat grass to a more densely vegetated cover dominated by bluebunch wheat grass. Much of this landscape is sparsely vegetated or consists of bare rock with some lichens and mosses.

This landscape is found on shallow colluvial materials or bedrock within the Interior bunch grass zone. The landscape is subjected to rapid runoff of moisture and is frequently found on southern exposures which compounds the droughty condition. Those areas with soil are very sensitive to disturbance as revegetation is very difficult due to severe moisture deficits. The vegetation is valuable for prevention of soil erosion.

Succession is quite similar to that of the bluebunch wheat grass - big sagebrush landscape (Figure 4.2) but is slower and the vegetative cover is sparser.

Common saskatoon - choke cherry vegetation landscape (SC)

The sparse vegetation of this landscape is dominated by common saskatoon and choke cherry sometimes with smooth sumac, Oregon-grape or ponderosa pine. The herb layer is absent. This landscape is associated with rubbly talus material on steep slopes within the Interior bunch grass zone. Moisture percolates easily to deeper areas of the soil where it is available to deeper rooting shrubs and trees. Little moisture is available near the soil surface so that a ground cover cannot establish.

No distinct successional trends are apparent for this landscape.

Big sagebrush - prairie sagebrush vegetation landscape (SS)
(see Figure 4.3)

The vegetation of this landscape succeeds from a grass forb cover (SS2) to a grass dominated cover with forbs and shrubs (SS6). This landscape is generally found on well drained soils with deep, fine textured, lacustrine materials within the Interior bunch grass zone. These sites generally have favourable moisture availability in the spring although during the summer these soils become very dry and moisture that reaches the soil, may be held at the surface, and evaporate. Organic matter in the soil may improve percolation of water to the rooting zone.

Severe disturbance may set succession back to a persistent shrub dominated cover (SS1). Succession and vegetation cover after disturbance are similar to that of the bluebunch wheat grass - big sagebrush landscape and the needle-and-thread grass - big sagebrush landscape.

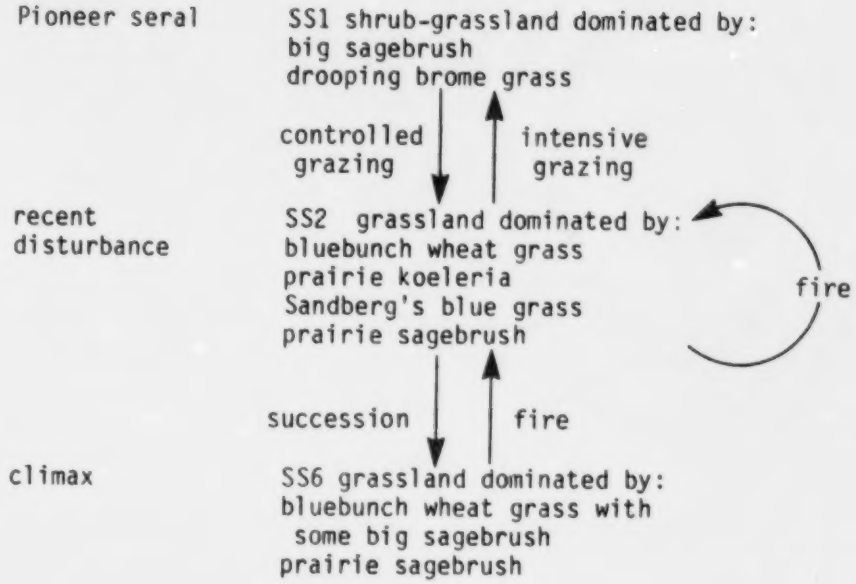

Figure 4.3 Successional trends of the Big sagebrush - prairie sagebrush vegetation landscape (SS)

Bluebunch wheat grass - big sagebrush vegetation landscape (WS)
(see Figure 4.4)

The vegetation of this landscape succeeds from a grass-forb cover (WS2) to a grass dominated cover with forbs and shrubs (WS6). This landscape is generally found on well drained soils with deep, medium textured morainal or colluvial materials within the Interior bunch grass zone. These sites have typical moisture availability for the zone, although this landscape may be found on southern exposures, or on shallow soils which are drier, more sensitive to disturbance and are slower to recover after disturbance. The soils are Orthic Brown Chernozems at lower elevations and Orthic Dark Brown Chernozems at upper elevations of the Interior bunch grass zone. The vegetation of these sites depends on available moisture in spring and is subjected to severe soil moisture deficits during the summer.

Due to limited moisture availability these sites are very slow to recover from disturbances. Usually after disturbance, the vegetation becomes dominated by persistent, competitive species such as big sagebrush.

A cover of big sagebrush (WS1) results following prolonged grazing of these sites at any successional stage. Severe overgrazing creates conditions of sparse grass and forb cover leaving the soil susceptible to erosion because of limited litter cover, little soil binding by roots and little interception of precipitation by vegetation and litter. As well little organic material accumulates, lowering soil fertility. Fire will remove big sagebrush from these areas, however, if bluebunch wheat grass or other species of the climax vegetation are not dominant after a fire, these sites may be reinvaded by big sagebrush.

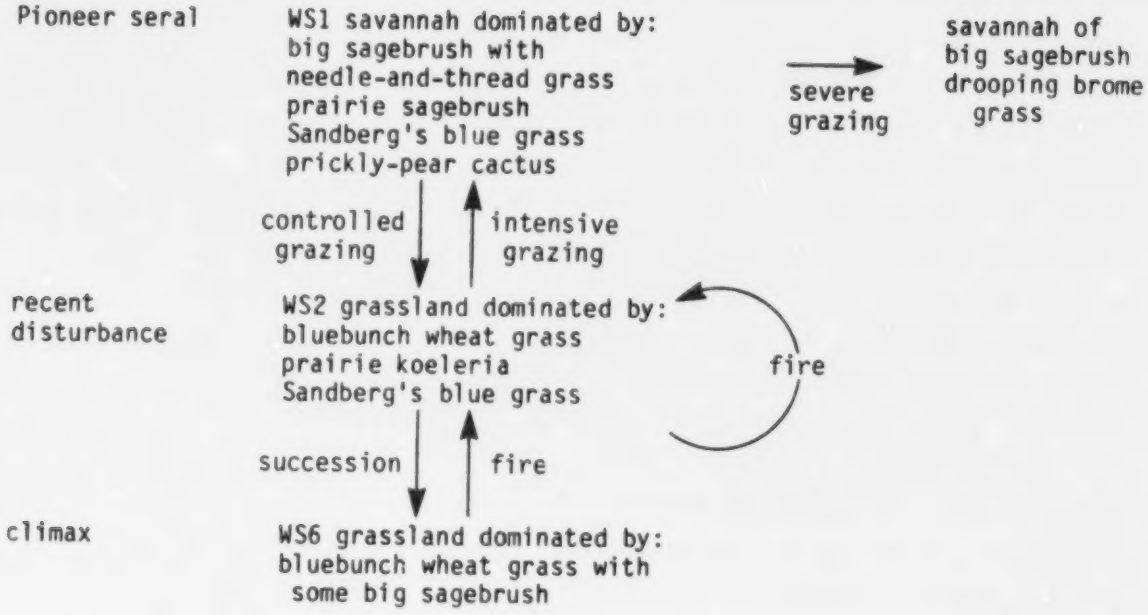

Figure 4.4 Successional trends of the Bluebunch wheat grass - big sagebrush vegetation landscape (WS)

4.4.2 INTERIOR ROCKY MOUNTAIN DOUGLAS-FIR ZONE: PONDEROSA PINE SUBZONE

Fire and grazing have been important influences on the nature of vegetation in this subzone in the past. Ground fires are believed to have burned through ponderosa pine stands at intervals of eight to twenty years (Franklin and Dyrness, 1973) before organized fire control. These consumed surface organic debris, including branches and downed trees, a portion of the understory vegetation and young tree seedlings (Franklin and Dyrness, 1973). Mature ponderosa pine and Rocky Mountain Douglas-fir are little affected by ground fire at any season (Strang, personal communication[1]). Ponderosa pine-grassland communities are highly flammable due to a heavy annual drop of large pine needles of high resin content (Biswell, 1973; Smaill, 1980). Without surface fires, fuels accumulate and wildfires are extremely damaging and difficult to control (Biswell, 1973). Repeated fires maintain stands in an open park-like structure (Brayshaw, 1965). Fire may stimulate the growth of grasses and forbs by releasing nutrients and by removing accumulated dead material which reduces space and light (Nyberg, 1979). Perennial grasses may be depressed in the first year following burning but recover quickly and by the third year equal or exceed pre-burn numbers and intensities (Strang, personal communication[1]). Common rabbitbrush and big sagebrush were found to be very susceptible to burning with little regrowth or recovery (Strang, personal communication[1]). Fire also promotes continued dominance of ponderosa pine in areas of Rocky Mountain Douglas-fir climax (Weaver, 1967). Burning at the wrong time of the year creates detrimental effects such as removal of foliage before depleted carbohydrate reserves are replenished (Nyberg, 1979). This allows invading species to establish and replace bluebunch wheat grass.

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[1]Strang, R. M., Personal communication. Forest Research Council, Secretariat on Forestry Research and Development, Province of British Columbia, 1981.

Grazing by livestock occurs throughout the Ponderosa pine subzone. Plant communities of this area offer best returns from grazing by domestic and wild ungulates (McLean et al., 1971). With heavy grazing, bluebunch wheat grass and rough fescue decrease in abundance, while Sandberg's blue grass, needle grasses, low pussytoes and shaggy fleabane increase, while drooping brome grass invades these areas (McLean et al., 1971). As well, knapweed has the potential to invade these sites to the exclusion of other plants.

It may take from 20 to 40 years for overgrazed ranges, in this subzone, to return to excellent range condition when fully rested. However, an alternative to long periods of rest is to graze during the season of least damage, that is fall or winter, in order to rehabilitate the range (McLean and Tisdale, 1972).

VEGETATION LANDSCAPES OF THE PONDEROSA PINE SUBZONE OF THE INTERIOR ROCKY MOUNTAIN DOUGLAS-FIR ZONE

Black cottonwood - white spruce vegetation landscape (CS)

The vegetation of this landscape leads from early stages of shrub dominated vegetation of alder, red-osier dogwood and black cottonwood to broad-leaved forests dominated by black cottonwood with a dense shrub layer of red-osier dogwood and finally to edaphic climax vegetation dominated by white spruce. This landscape is found on floodplain areas which generally have coarse-textured, well aerated soils. The soils are frequently Cumulic Regosols.

Rocky Mountain Douglas-fir - Rocky Mountain juniper vegetation landscape (DJ)

The vegetation of this landscape is dominated by Rocky Mountain Douglas-fir, Rocky Mountain juniper, common saskatoon and bluebunch wheat grass,

although on moister sites Rocky Mountain maple, pine grass and common moss may be present.

This landscape is found in gulleys throughout the Ponderosa pine subzone of the Interior Rocky Mountain Douglas-fir zone. These sites are subjected to more favourable moisture conditions than surrounding sites allowing denser tree regeneration and lush shrub and herb growth.

Successional trends were not determined for this landscape.

Rocky Mountain Douglas-fir - common selaginella vegetation landscape (DS)

The vegetation of this landscape leads from a cover of bluebunch wheat grass and common selaginella (growing on rubbly material) to an open forest dominated by Rocky Mountain Douglas-fir with an understory of rough fescue and pine grass. This landscape is small in areal extent. Its occurrence is limited to the south side of the Tranquille River within the Ponderosa pine subzone of the Rocky Mountain Douglas-fir zone. It is found on very steep, rubbly colluvial material, on a northeast facing slope. Moisture percolation is rapid, creating relatively severe moisture deficits during much of the growing season. The rate of succession is expected to be very slow.

The sites on which this landscape is found are sensitive. If the vegetation is removed these unstable materials may erode. Establishment of vegetation after disturbance is difficult.

Ponderosa pine - snowbush ceanothus vegetation landsape (PC)
(see Figure 4.5)

The vegetation of this landscape succeeds from a lush shrub dominated community (PC2) to a dense forested community with a sparse understory (PC6). This landscape is found in moist, lower slope positions with deep, nutrient rich soils of fluvial or colluvial materials within the Ponderosa pine subzone of the Interior Rocky Mountain Douglas-fir zone. The increased moisture of these sites allows for productive growth of vegetation. This landscape occurs on gently sloped areas. The soils are Orthic Gray Luvisols or Brunisolic Gray Luvisols.

Disturbance results in a lush shrub-grass-forb cover. Seral forests are dominated by ponderosa pine, Rocky Mountain Douglas-fir, Oregon-grape, pine grass and kinnikinnick while the climax commonly consists of closed stands of Rocky Mountain Douglas-fir with a sparse understory. As shading by the canopy greatly restricts understory growth in later forested stages of this landscape, opening the canopy increases the production of shrubs and herbs. Certain species, such as snowbush ceanothus, must be stimulated by fire to germinate.

Ponderosa pine - rough fescue vegetation landscape (PF)
(see Figure 4.6)

The vegetation of this landscape succeeds from a grassland cover (PF2) to forested communities (PF6). This landscape is usually found on deep, well drained soils of morainal or colluvial materials, although it may be found on shallow soils. This landscape is found in the Ponderosa pine subzone of the Interior Rocky Mountain Douglas-fir zone, and is present only in the eastern portions of the study area. This landscape is found on various exposures although it is generally found on gentle terrain on the upper parts of hills. The soils of this landscape are Eutric Brunisols under forested cover and Orthic Black Chernozems under grassland cover.

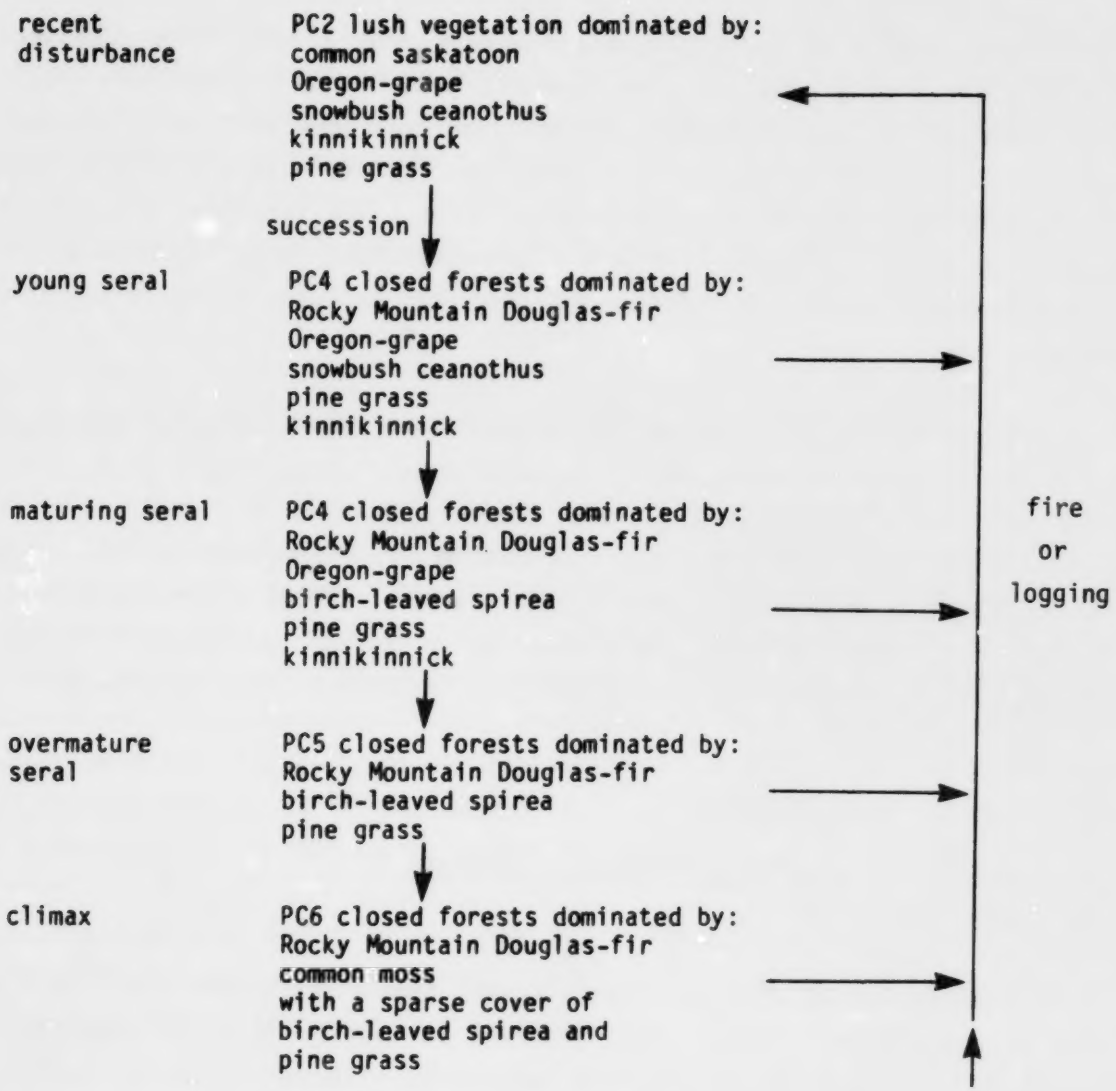

Figure 4.5 Successional trends of the Ponderosa pine - snowbush ceanothus vegetation landscape (PC)

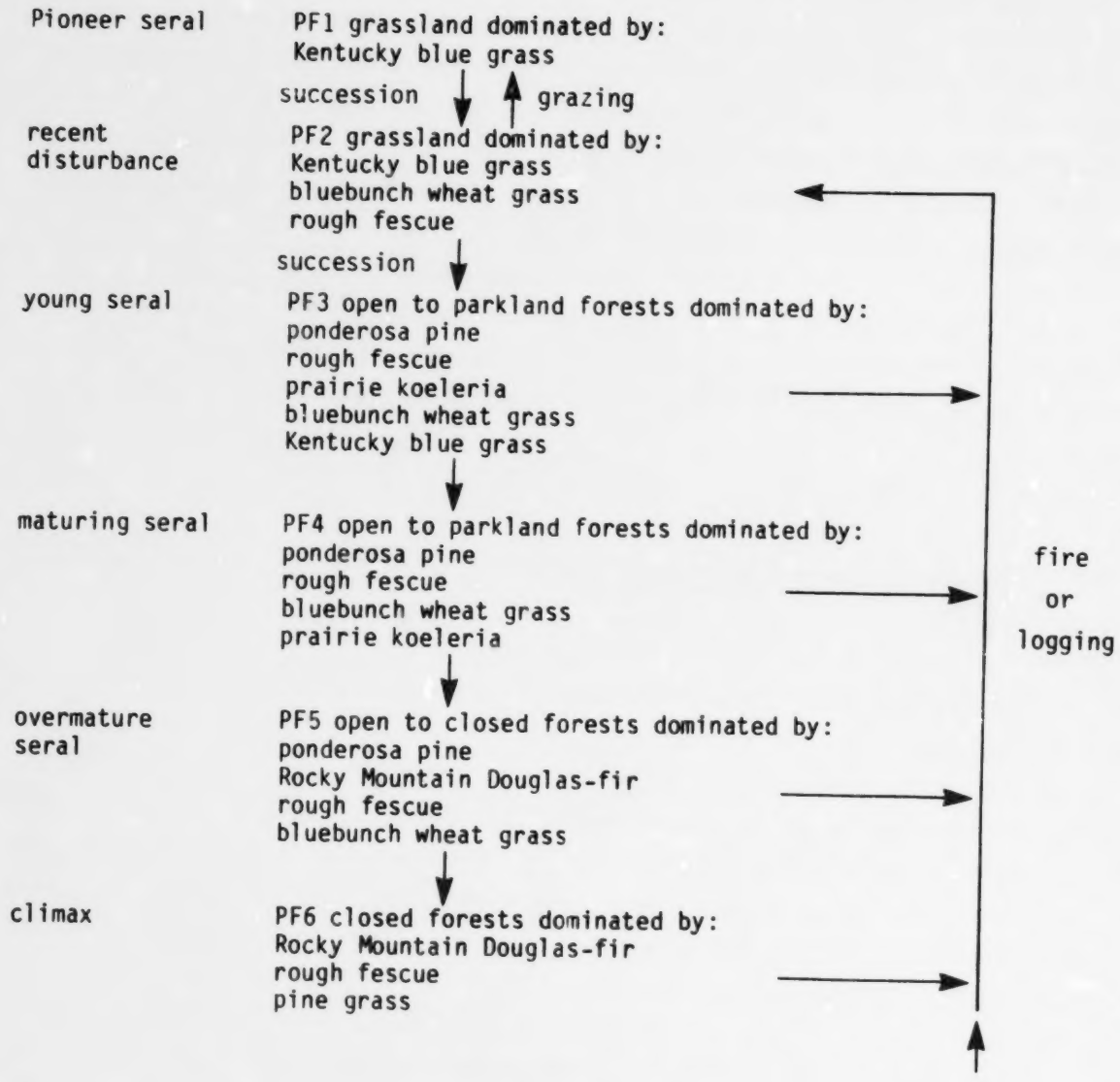

Figure 4.6 Successional trends of the Ponderosa pine - rough fescue vegetation landscape (PF)

After disturbance to the forested stages, this landscape has a cover dominated by bluebunch wheat grass, rough fescue and Kentucky blue grass. Intensive grazing usually leaves a cover dominated by Kentucky blue grass, which persists for a long period of time before other grasses can invade, because of its competitive ability. Big sagebrush may dominate at lower elevations of this vegetation landscape after grazing. Seral forests are usually dominated by open stands of ponderosa pine, bluebunch wheat grass and rough fescue while climax stands consist of closed stands of Rocky Mountain Douglas-fir, pine grass and rough fescue.

In the forested communities, opening of the canopy allows better production of understory vegetation, particularly bluebunch wheat grass and rough fescue, and prevents pine grass from becoming dominant.

Ponderosa pine - common rabbitbrush vegetation landscape (PR)
(see Figure 4.7)

The vegetation of this landscape succeeds from a persistent shrub-grass dominated vegetation (PR2) to an open forested community (PR6). This landscape occurs on rapidly drained, shallow soils of morainal or colluvial materials often intermixed with areas of bedrock. These sites are quite droughty especially since this landscape commonly occurs on southern exposures. The resultant severe moisture deficits create a very slow rate of succession. Tree establishment is quite slow after disturbance. The soils of these sites are Orthic Eutric Brunisols.

After disturbance to the forested stages of this landscape a cover of common rabbitbrush, common saskatoon and bluebunch wheat grass dominates, while the rocky areas frequently have shrubby penstemon, lance-leaved stonecrop, common selaginella and round-leaved alumroot. With a more severe fire the sites with shallow soil may develop a cover of weedy species such as drooping brome grass, yarrow and Pacific field wormwood.

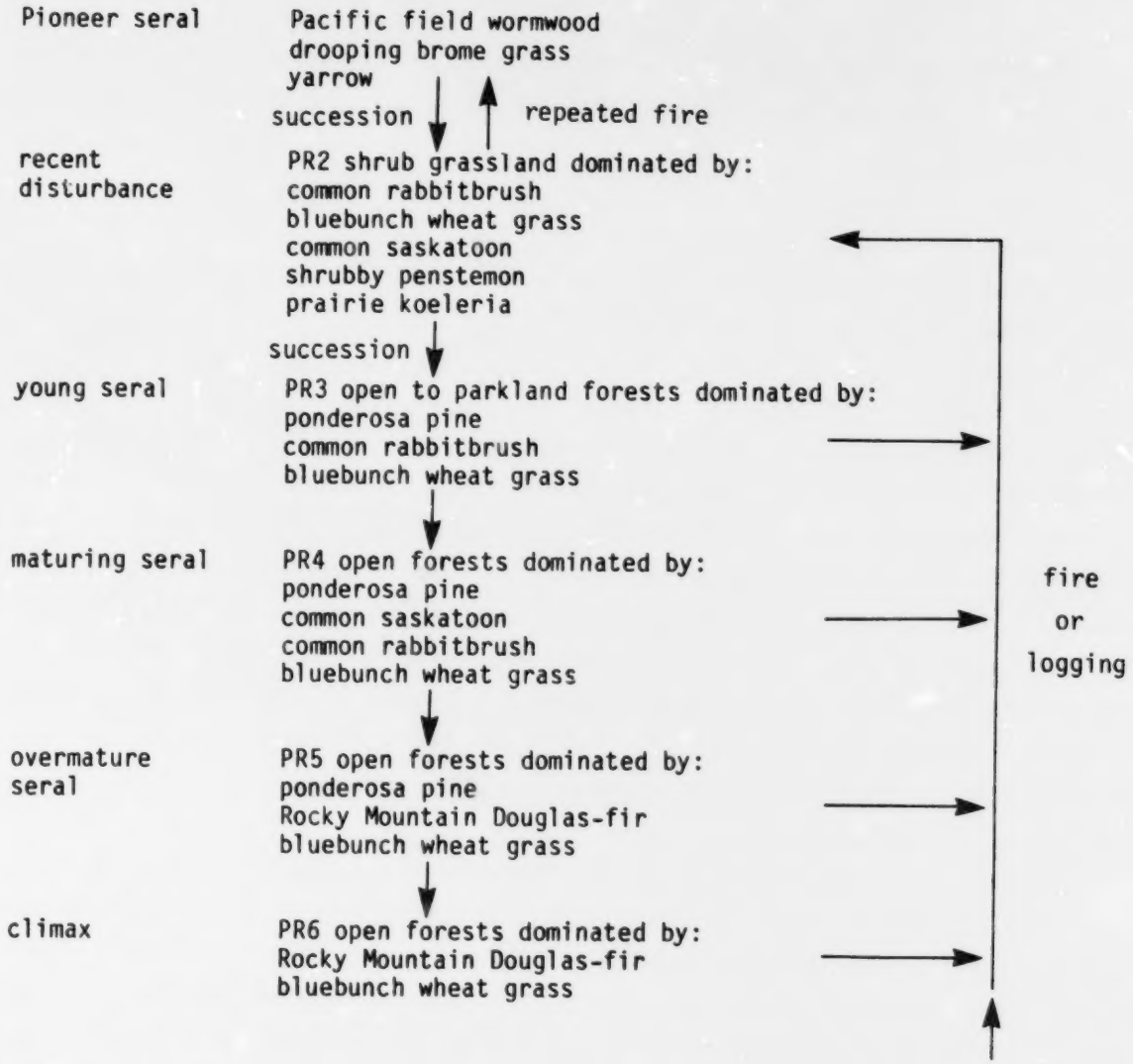

Figure 4.7 Successional trends of the Ponderosa pine - common rabbitbrush vegetation landscape (PR)

Seral forested stages are dominated by open forests of ponderosa pine with common rabbitbrush and bluebunch wheat grass. Climax stands are dominated by open stands of Rocky Mountain Douglas-fir and bluebunch wheat grass.

Beneath the open tree canopy, the understory vegetation usually receives sufficient light but understory production is mainly restricted by moisture availability.

Ponderosa pine - big sagebrush vegetation landscape (PS)
(see Figure 4.8)

The vegetation of this landscape generally succeeds from a grassland cover (PS2) to an open forested cover with a grass understory (PS6). This landscape is generally found on deep, well drained soils on morainal, colluvial, fluvial or lacustrine material at lower elevations of the Ponderosa pine subzone of the Interior Rocky Mountain Douglas-fir zone. This landscape is commonly found on southeast to southwest exposures. It is subjected to severe moisture deficits in the summer months. Shrubs or trees that establish are often valuable in providing shade that allows establishment of trees. Succession to forested stages is generally very slow. The soils are Eutric Brunisols under forested cover and Orthic Dark Brown Chernozems under grassland cover.

After a major disturbance of the forested stand the vegetation becomes dominated by grasses such as bluebunch wheat grass. If intensive grazing occurs at this time the vegetation may become similar to the bluebunch wheat grass - big sagebrush landscape, where, big sagebrush dominates (PS1). Big sagebrush will lose its dominance through discontinued grazing or fire.

In early stages of succession which consist of an open forest cover of ponderosa pine, domination by big sagebrush may result from intensive grazing. Climax forests generally are dominated by open stands of Rocky Mountain Douglas-fir with an understory of bluebunch wheat grass.

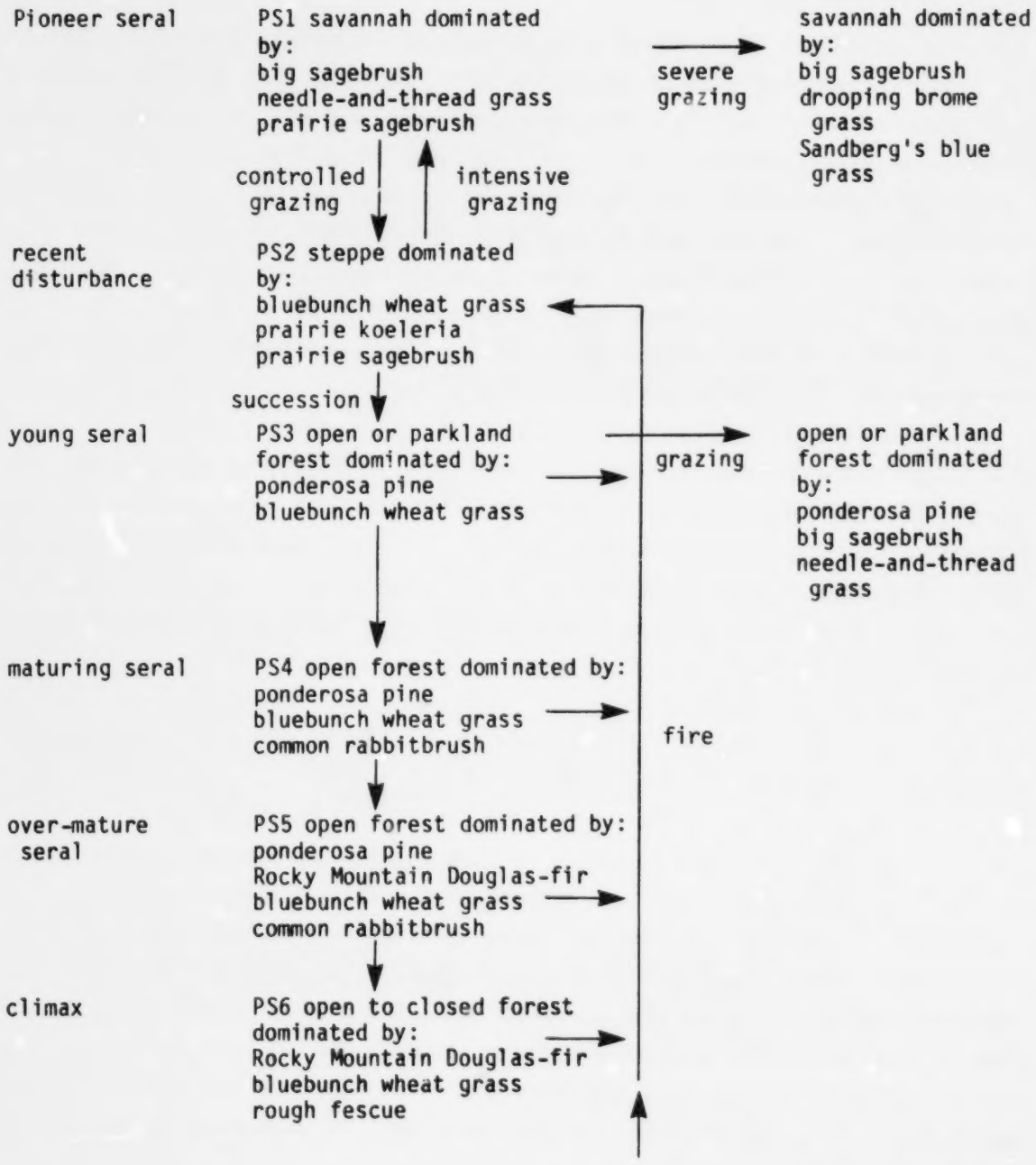

Figure 4.8 Successional trends of the Ponderosa pine - big sagebrush vegetation landscape (PS)

Ponderosa pine - bluebunch wheat grass vegetation landscape (PW) (see Figure 4.9)

The vegetation of this landscape succeeds from a grass dominated cover to a forested community with a grass dominated understory. This landscape is generally found within the Ponderosa pine subzone of the Interior Rocky Mountain Douglas-fir zone, on deep, well drained soils of morainal or colluvial materials, although it may be found on shallow soils. This landscape frequently occurs on southeast to southwest facing slopes which may create more severe moisture deficits and a slower rate of succession for this landscape than on other sites. This landscape has average moisture availaiblity for this subzone and a normal rate of succession. The soils associated with this landscape are Eutric Brunisols or Orthic Gray Luvisols.

After major disturbance a cover dominated by bluebunch wheat grass and common saskatoon establishes. Ponderosa pine dominates seral stages with an understory of bluebunch wheat grass. Ground fires remove tree regeneration, litter and needles, allowing more light and stimulating understory growth. Grazing may allow weedy species such as timber milk-vetch to become common.

Saline pond vegetation landscape (SP)

The vegetation of this landscape is dominated by salt tolerant plants such as Pursh's sea-blite, with red goosefoot and foxtail barley (SP6). This landscape is found in a depressional area within the Ponderosa pine subzone of the Interior Rocky Mountain Douglas-fir zone. In early spring this site receives runoff water from the surrounding hills and is usually inundated. By summer this water has evaporated concentrating salts at the surface of the soil. Salinity in the soil tends to decrease away from the centre of the depression. This marsh landscape may sometimes be unvegetated towards the middle of the depressional area.

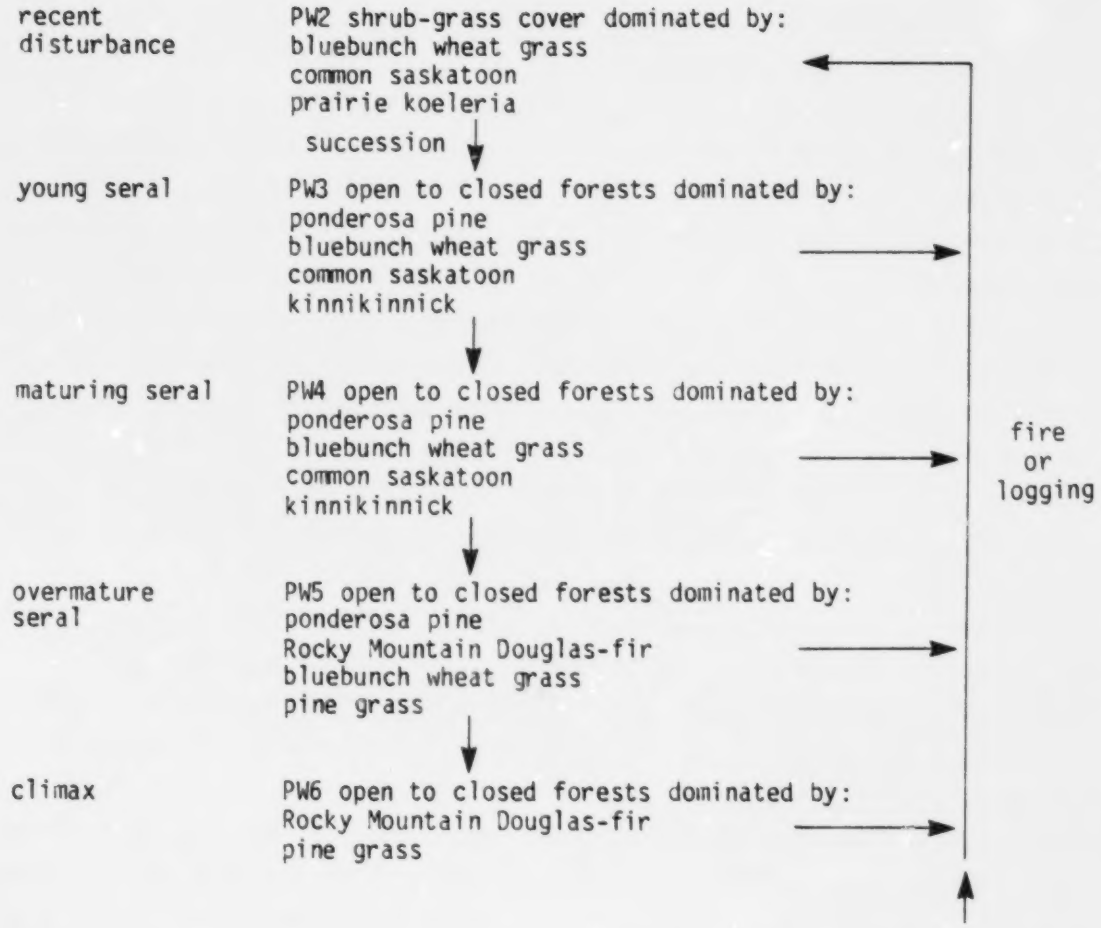

Figure 4.9 Successional trends of the Ponderosa pine - bluebunch wheat grass vegetation landscape (PW)

4.4.3 INTERIOR ROCKY MOUNTAIN DOUGLAS-FIR ZONE: LODGEPOLE PINE SUBZONE

Areas within the Lodgepole pine subzone have been subjected to fires, logging and grazing. Due to widespread fires in the past much of this subzone is presently dominated by the seral species lodgepole pine and trembling aspen (McLean, 1979). Regeneration in post-fire succession occurs either from underground reproductive structures or viable seed present in the soil or disseminated by wind, or animals (McLean, 1969). There is a close relationship between root system characteristics and the relative fire resistance of species found (McLean, 1969). Resistant species are those that have rhizomes which grow between 5 and 13 cm below the mineral soil surface such as common snowberry and birch-leaved spirea, and species with taproots that are able to regenerate from below their crowns, such as lupines and timber milk-vetch (McLean 1969). Species with air-borne seed such as fireweed, showy aster, heart-leaved arnica and hawkweed (McLean, 1969) readily invade burned areas.

Selective or clearcut logging is fairly common in this subzone. Logging opens up the tree canopy allowing more light to reach the forest floor. It has been shown that a significant correlation exists between crown cover and total herbage production (Dodd et al., 1972). Species that become abundant after logging vary with elevation. At lower elevations, bluebunch wheat grass, prairie koeleria, Kentucky blue grass and dandelion may increase while at higher elevations lupines, timber milk-vetch and heart-leaved arnica increase (McLean, 1979). In logged areas, pine grass is susceptible to heavy grazing and is often partially replaced by heart-leaved arnica and dandelion.

This subzone supplies much of the forest grazing in the study area with the dominant species utilized being pine grass and forbs.

VEGETATION LANDSCAPES OF THE LODGEPOLE PINE SUBZONE OF THE INTERIOR ROCKY MOUNTAIN DOUGLAS-FIR ZONE

Trembling aspen - pine grass vegetation landscape (AP)
(see Figure 4.10)

The vegetation of this landscape succeeds from a shrub-grass-forb cover (AP2) through broad-leaved seral forest stages (AP3-AP5) to coniferous forest with an understory of shrubs, grass and forbs (AP6). The landscape is found on deep, well drained soils of fluvial materials, within the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone. This landscape is associated with gently sloping areas. The soils are Eutric Brunisols. These sites may be subject to moisture deficits in the growing season. The rate of succession is average.

The vegetation of this landscape and the successional trends are similar to that of the Lodgepole pine - pine grass landscape (LP) with trembling aspen replacing lodgepole pine as the dominant seral tree species.

After disturbance, the cover is dominated by trembling aspen in the shrub layer, fireweed and pine grass. With grazing, weedy species such as clover become common. Repeated fires creates a dense trembling aspen shrub cover because of suckering. Seral forests are dominated by trembling aspen, soopolallie, roses, American vetch, cream-coloured peavine and pine grass while climax stands have Rocky Mountain Douglas-fir, birch-leaved spirea, roses and pine grass.

Opening of the tree canopy may increase understory production although the increase may only be significant in the stages with prominent coniferous cover (AP5, AP6).

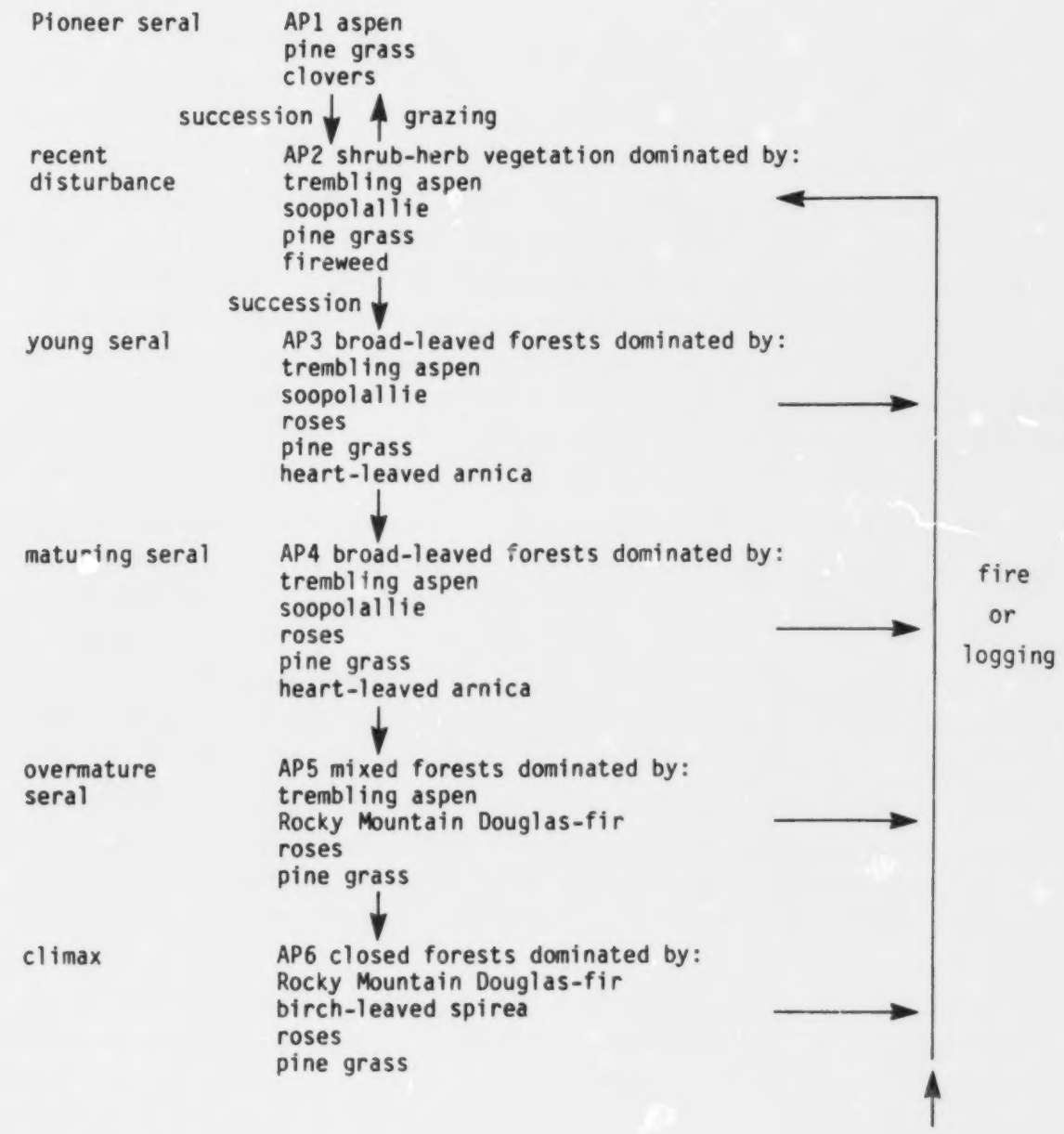

Figure 4.10 Successional trends of the Trembling aspen - pine grass vegetation landscape (AP)

Trembling aspen - white spruce vegetation landscape (AS)
(see Figure 4.11)

The vegetation of this landscape succeeds from a lush shrub-herb cover (AS2) through seral forest stages of broad-leaved cover (AS3-AS5) to a coniferous forest cover with a rich understory (AS6). This landscape occurs on rich, deep, well drained soils of fluvial materials in the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone. The landscape is found in receiving positions which have favourable moisture availability for lush shrub and herb growth. These sites have a relatively fast rate of succession. The soils are usually Orthic Eutric Brunisols.

After disturbance, a cover dominated by trembling aspen in the shrub layer, common snowberry, pine grass and cream-coloured peavine occurs. Seral forests are dominated by trembling aspen, common snowberry, pine grass and cream-coloured peavine while climax forests are dominated by white spruce, common snowberry and pine grass.

Opening the tree canopy in the coniferous forested stages (AS5, AS6) increases understory production.

Paper birch - trembling aspen vegetation landscape (BA)
(see Figure 4.12)

The vegetation of this landscape succeeds from a lush, shrub dominated cover (BA2), through broad-leaved forests with a lush understory, to closed coniferous forests with a relatively rich understory. This landscape is found on relatively gently sloping areas, in receiving positions within the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone. This landscape generally has deep, moderately well drained soils of morainal materials. The soils are nutrient rich and have favourable moisture availability. This is

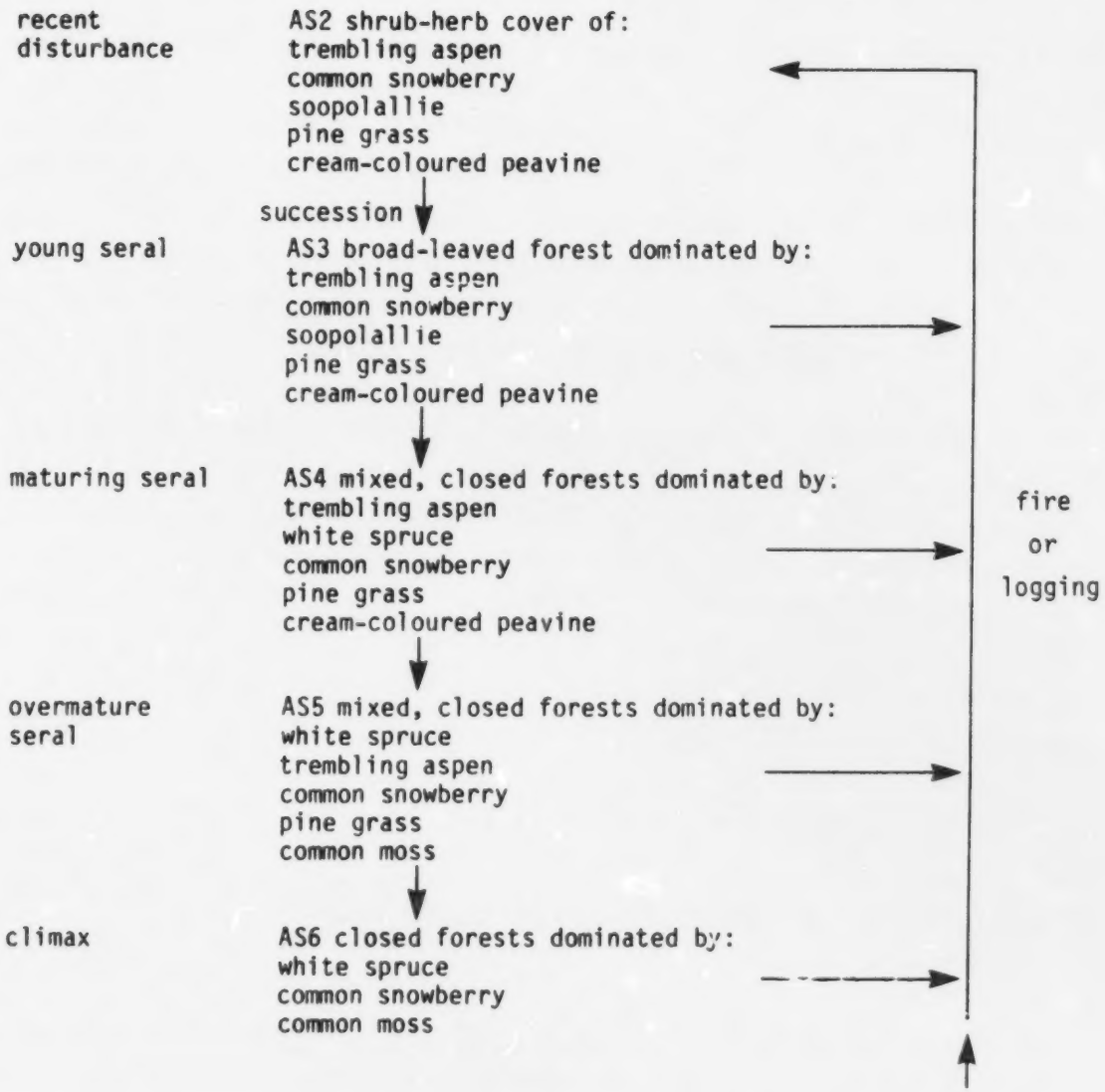

Figure 4.11 Successional trends of the Trembling aspen - white spruce vegetation landscape (AS)

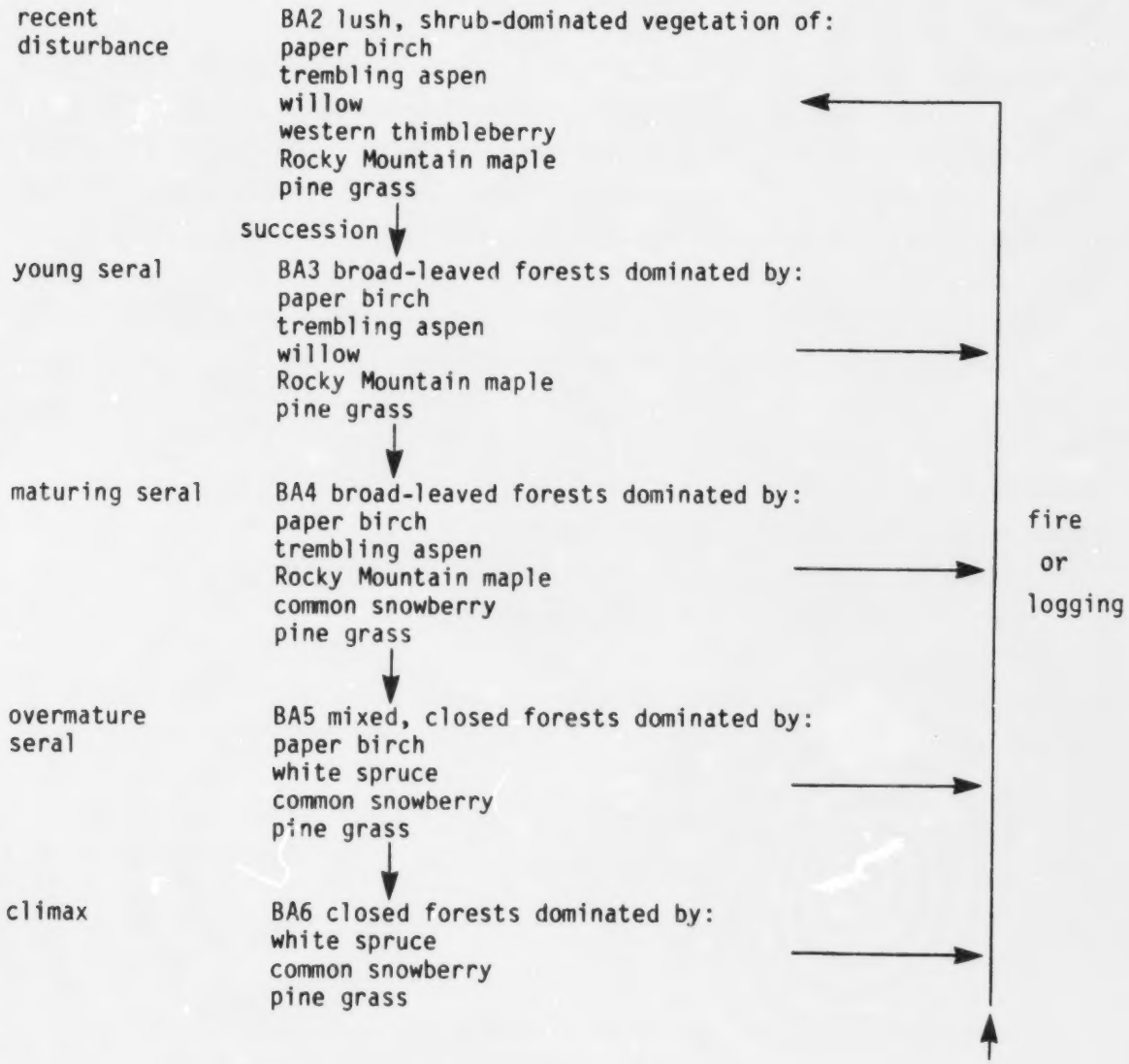

Figure 4.12 Successional trends of the Paper birch - trembling aspen vegetation landscape (BA)

reflected in lush plant growth. The soils are Orthic Gray Luvisols or Brunisolic Gray Luvisols. These sites have a relatively fast rate of succession.

After disturbance, a cover dominated by a dense shrub cover of paper birch, trembling aspen, willow and western thimbleberry, and pine grass establishes. Seral forests are dominated by paper birch, trembling aspen, Rocky Mountain maple and pine grass, while the climax forests are dominated by white spruce, and common snowberry.

Opening of the forest canopy, particularly when conifers dominate, increases production of understory vegetation.

Cattail marsh vegetation landscape (CM)

The vegetation of this landscape is dominated by common cattail.

This landscape is found at the edge of ponds and lakes within the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone.

In these areas the vegetation is rooted in mineral substrate and the sites have high water tables for much of the year. This landscape occupies a small part of the study area.

Black cottonwood - white spruce vegetation landscape (CS)
(see Figure 4.13)

The vegetation of this landscape succeeds from a lush shrub dominated cover (CS2), through broad-leaved seral forest stages with a lush shrub cover (CS3-CS5), to a closed coniferous forest with lush shrub and herb cover (CS6). This landscape is found on floodplain areas of major streams and rivers within the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone. These sites may be subject to cold air drainage and may receive moisture from upslope as well as from seasonal flooding. A seasonally high water table may exist. Because of good moisture availability these sites have high shrub production. The soils are generally Cumulic Regosols but may be Gleyed Regosols.

After disturbance, a cover establishes dominated by red-osier dogwood, alder, western thimbleberry and horsetails. Seral forests are dominated by black cottonwood, paper birch, red-osier dogwood and horsetails while climax forests are dominated by white spruce and red-osier dogwood.

Opening of the forest canopy in coniferous-dominated stages increases understory production of shrubs and herbs.

Rocky Mountain Douglas-fir - redstem ceanothus vegetation landscape (DC)
(see Figure 4.14)

After disturbance the vegetation is dominated by lush shrub-herb growth (DC2) and succeeds to a dense forested community with a sparse understory (DC6). This landscape has limited occurrence within the study area, in the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone. It occurs on deep, well drained soils of morainal material.

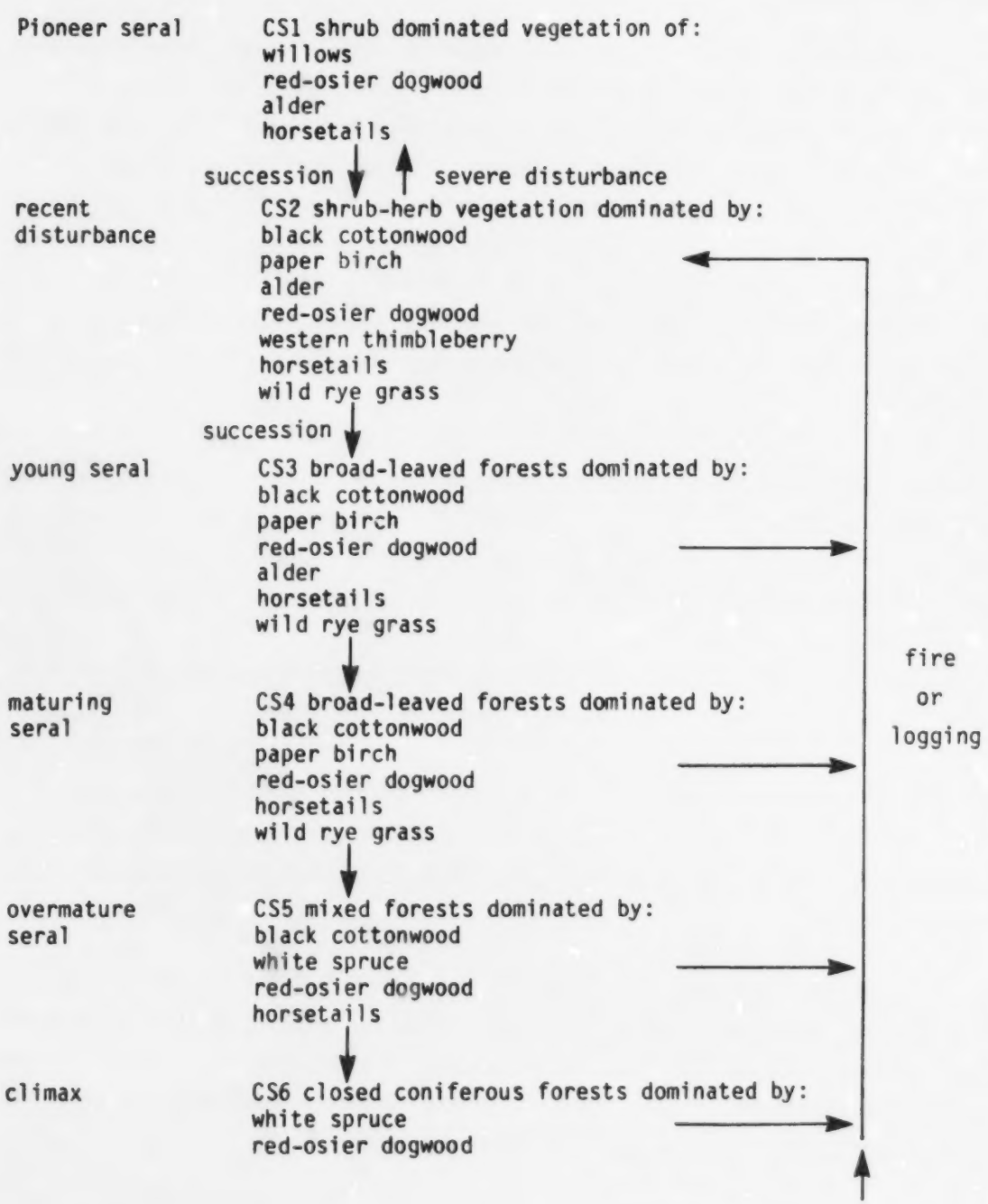

Figure 4.13 Successional trends of the Black cottonwood - white spruce vegetation landscape (CS)

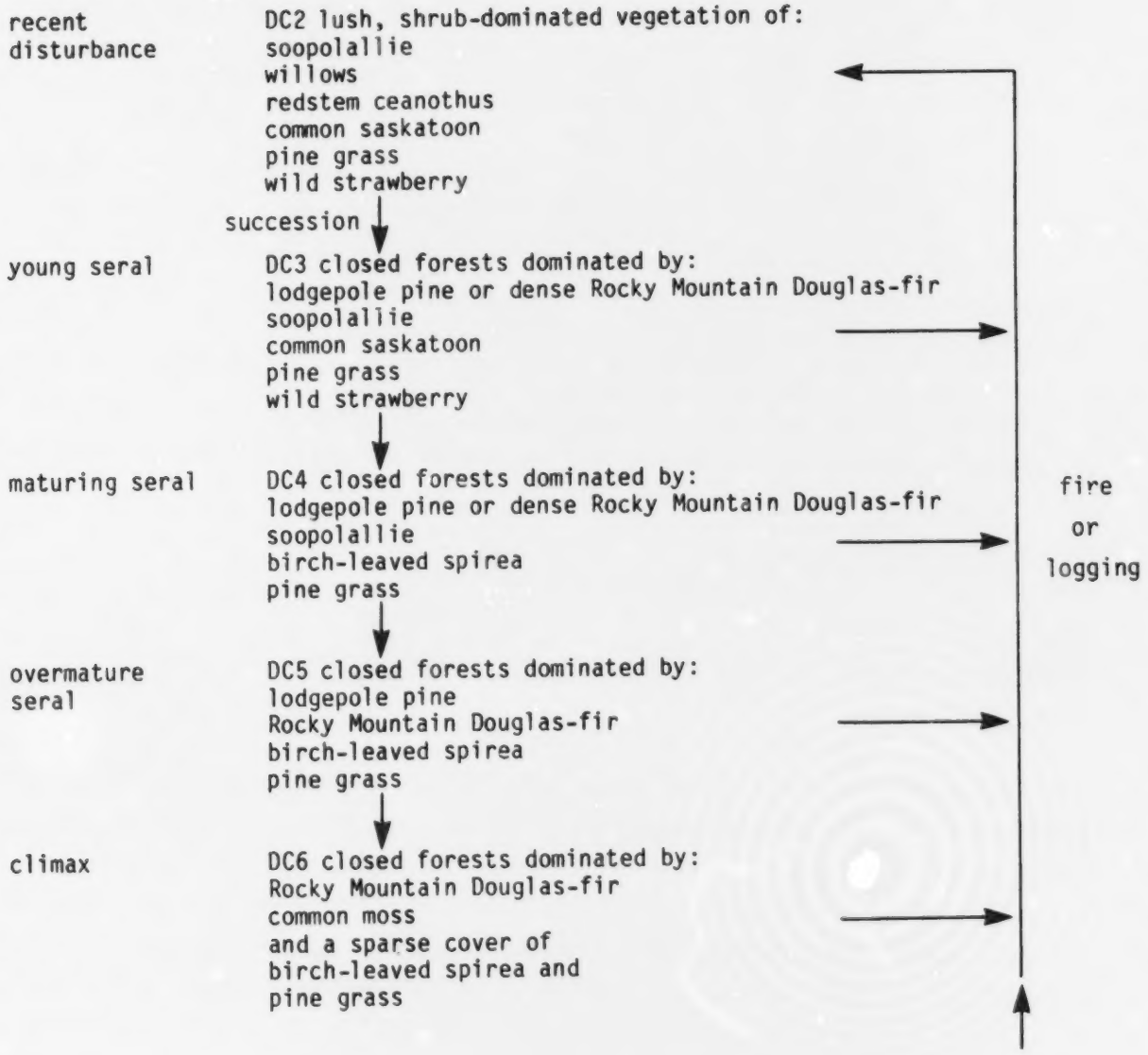

Figure 4.14 Successional trends of the Rocky Mountain Douglas-fir - redstem ceanothus vegetation landscape (DC)

This landscape is similar to the lodgepole pine - pine grass vegetation landscape (LP) except it has richer understory growth in early stages. This landscape occurs in an area of a moister climate than the LP landscape and as well receives more solar radiation as it is on a south to southeast facing slope. Production of shrub and herb growth is greater and the rate of succession is faster than on the LP landscape.

Disturbance of forested stages of this landscape will create a shrub-herb dominated cover of soopolallie, willows, redstem ceanothus and pine grass. Seral forests usually have an understory of soopolallie and pine grass while the climax stands are dominated by closed forests of Rocky Mountain Douglas-fir, pine grass and common moss.

Opening of the canopy in forested successional stages generally leads to increased production of understory shrubs and herbs. Redstem ceanothus seeds must be stimulated by fire to germinate.

Rocky Mountain Douglas-fir - moss vegetation landscape (DM)
(see Figure 4.15)

The vegetation of this landscape succeeds from a grass-forb cover (DM2) to a dense forest with a continuous understory of moss (DM6). This landscape is found on steep, north to east facing slopes with deep, well drained soils of colluvial or morainal material within the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone. Moisture availability is good as these sites are cool and receive less solar radiation than other aspects. The sites have a relatively fast rate of succession. The soils are Orthic Gray Luvisols or Brunisolic Gray Luvisols.

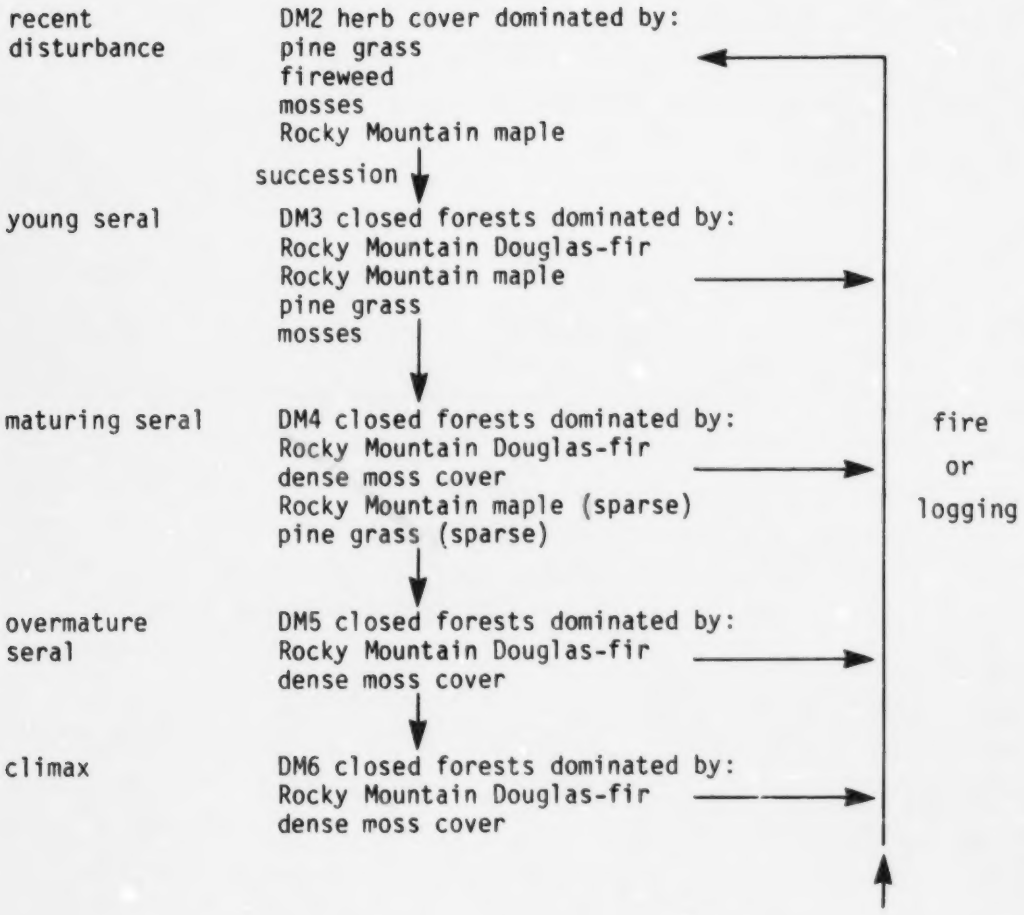

Figure 4.15 Successional trends of the Rocky Mountain Douglas-fir - moss vegetation landscape (DM)

After disturbance, fireweed and pine grass dominate. Seral forests are dominated by Rocky Mountain Douglas-fir, Rocky Mountain maple and pine grass while the climax is dominated by Rocky Mountain Douglas-fir and mosses.

Opening the tree canopy in later stages will allow only some increase in production of Rocky Mountain maple and pine grass.

Rocky mountain Douglas-fir - bluebunch wheat grass vegetation landscape (DW) (see Figure 4.16)

The vegetation of this landscape succeeds from a grass dominated community (DW2) to a forested community with a grass dominated understory (DW6). This landscape is found on shallow, well to rapidly drained soils of colluvial or morainal material. It is frequently associated with southeast to southwest facing slopes although it may be found on other aspects, or on knolls within the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone. These sites are relatively droughty and the rate of succession is slow because of considerable moisture deficits.

After disturbance a cover dominated by bluebunch wheat grass and common saskatoon establishes. Grazing at this stage results in a cover dominated by timber milk-vetch and yarrow. Seral forests are dominated by open stands of Rocky Mountain Douglas-fir, common saskatoon and bluebunch wheat grass while the climax is dominated by closed stands of Rocky Mountain Douglas-fir and pine grass.

Opening the tree canopy allows better production of understory shrubs and herbs than beneath closed canopies and allows bluebunch wheat grass and common saskatoon to be present instead of solid stands of pine grass.

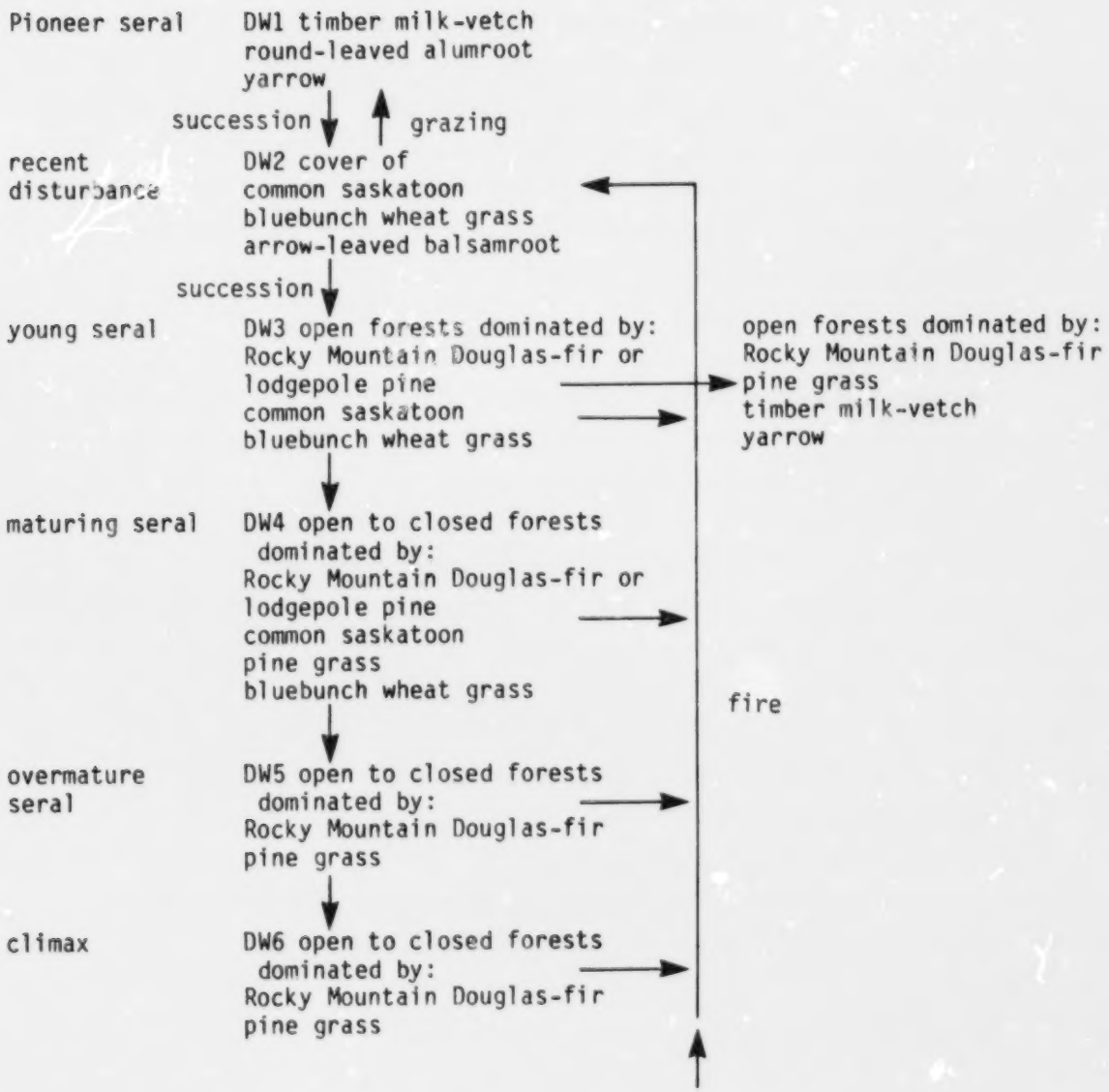

Figure 4.16 Successional trends of the Rocky Mountain Douglas-fir - bluebunch wheat grass vegetation landscape (DW)

Lodgepole pine - pine grass vegetation landscape (LP)
(see Figure 4.17)

The vegetation of this landscape succeeds from a shrub-herb (LP2) community to a closed forest community with a moderately rich understory vegetation (LP6). This widespread landscape is found on mesic sites within the Lodgepole pine subzone of the Rocky Mountain Interior Douglas-fir zone. This landscape is found on deep, well drained soils of morainal and colluvial materials, and generally is found on gently sloping areas of various aspects. These sites are subject to moisture deficits during the summer. The rate of succession is usually average and recovery of vegetation after disturbance is relatively good.

After disturbance, a cover dominated by pine grass and fireweed occurs. At higher elevations within this landscape American red raspberry and showy aster may be common. At lower elevations bluebunch wheat grass may be common. Grazing at this stage allows weedy species such as common dandelion, thistles and yarrow to establish. Seral forests are generally dominated by lodgepole pine, soopolallie, roses, showy aster and pine grass while climax stands are dominated by closed forests of Rocky Mountain Douglas-fir, birch-leaved spirea, pine grass and common moss. Seral forested communities usually have good productivity of understory shrubs and herbs. Opening of the canopy allows better understory growth. This is particularly true for communities dominated by Rocky Mountain Douglas-fir.

After disturbance of a young seral stage, if no lodgepole pine seeds are present, trembling aspen may establish and dominate.

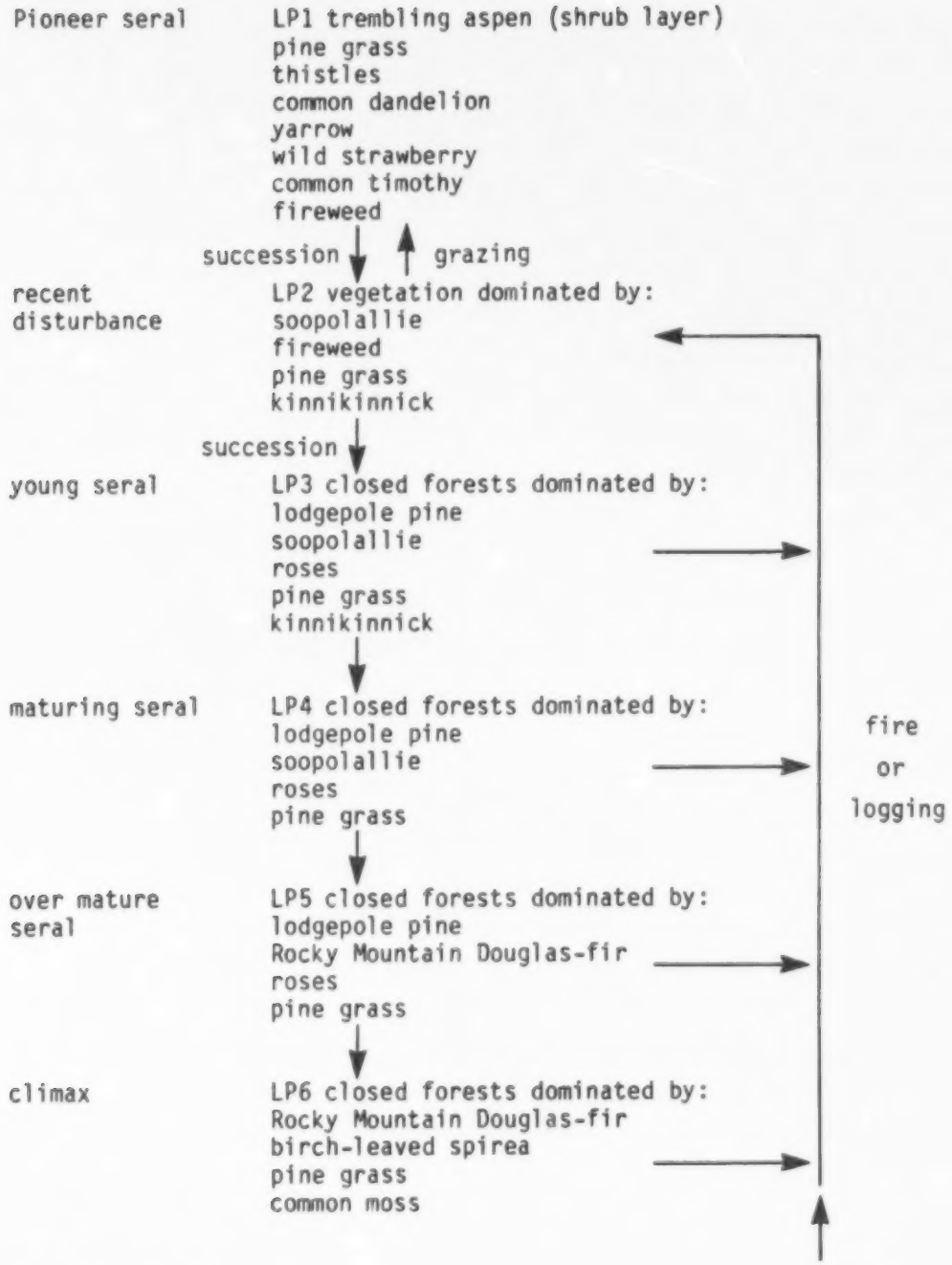

Figure 4.17 Successional trends of the Lodgepole pine - pine grass vegetation landscape (LP)

Lodgepole pine - spruce vegetation landscape (LS)
(see Figure 4.18)

The vegetation of this landscape succeeds from a shrub-herb cover (LS2) to a closed forest with a grass-moss understory cover (LS6). This landscape is found in cool, lower slope areas in which cold air pools. This landscape is found on gently sloping sites with deep, well to moderately well drained soils of fluvial or morainal materials. Moisture availability is good on these sites creating a relatively fast rate of succession. The soils are Orthic Gray Luvisols or Brunisolic Gray Luvisols.

After disturbance to the forested stages a cover dominated by soopolallie, pine grass, fireweed and dwarf blueberry establishes. Seral forests are dominated by lodgepole pine, soopolallie, pine grass and dwarf blueberry while climax forests are dominated by spruce, dwarf blueberry and moss.

Opening of the tree canopy in the forested stages creates a more productive understory cover.

Sedge fen vegetation landscape (SF)

The vegetation of this landscape is dominated by sedges. This landscape is found in depressional areas which have high water tables for much of the year. Mineral rich groundwater seeps into these areas from the surrounding slopes. The vegetation in these areas is rooted in organic soil material.

This landscape is found within the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone and is limited in areal extent.

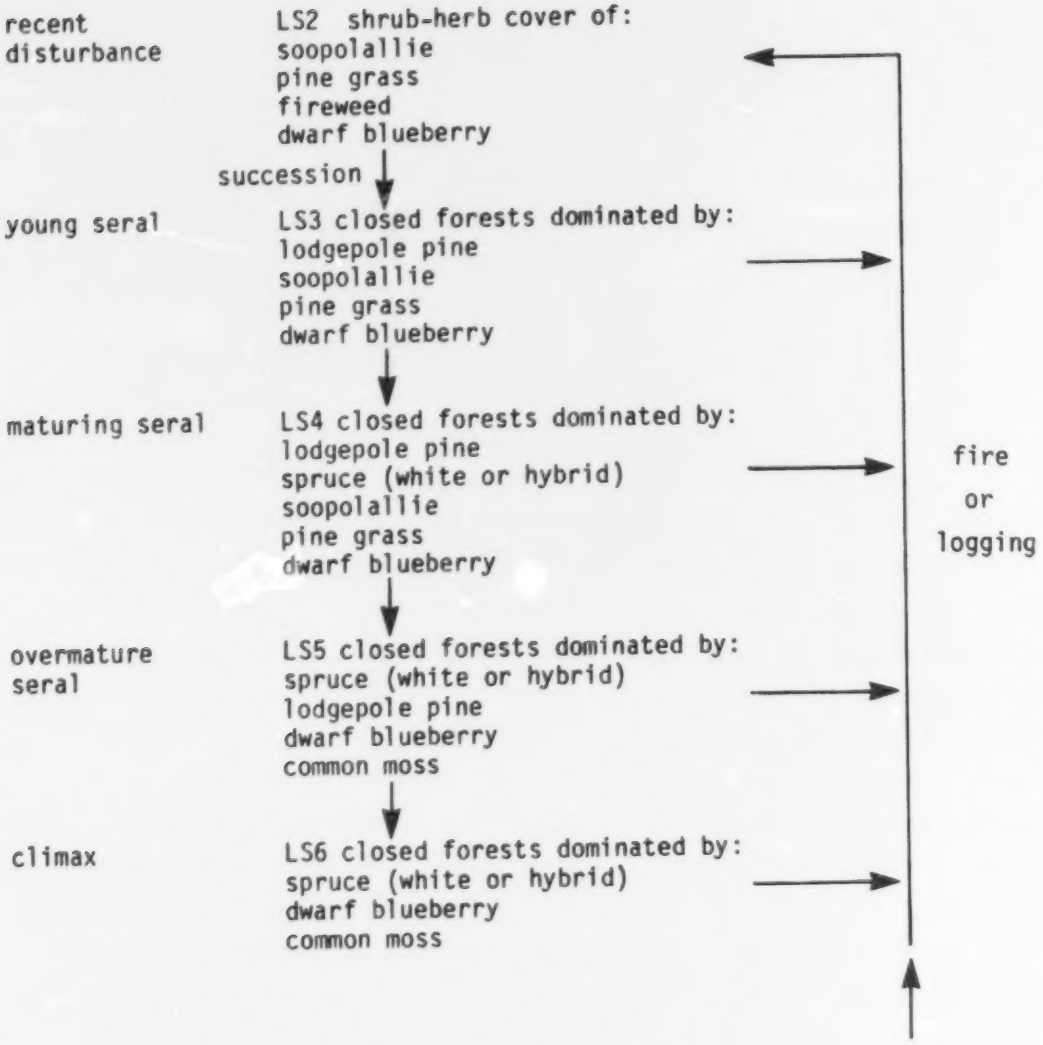

Figure 4.18 Successional trends of the Lodgepole pine - spruce vegetation landscape (LS)

4.4.4 SUBALPINE ENGELMANN SPRUCE - ALPINE FIR ZONE: ROCKY MOUNTAIN DOUGLAS-FIR - LODGEPOLE PINE SUBZONE

VEGETATION LANDSCAPES OF THE ROCKY MOUNTAIN DOUGLAS-FIR - LODGEPOLE PINE SUBZONE OF THE SUBALPINE ENGELMANN SPRUCE - ALPINE FIR ZONE

Lodgepole pine - Rocky Mountain Douglas-fir vegetation landscape (LD) (see Figure 4.19)

The vegetation of this landscape succeeds from a shrub-herb cover (LD2) to a closed forest with a continuous moss cover in the understory (LD6). This landscape generally occurs on steeply sloping areas with shallow, well to rapidly drained soils of colluvial or morainal material within the Rocky Mountain Douglas-fir - lodgepole pine subzone of the Subalpine Engelmann spruce - alpine fir zone. These sites are generally droughty so that the rate of succession is relatively slow.

After disturbance to the forested stage, a cover dominated by soopolallie, fireweed, pine grass and kinnikinnick establishes. Seral forested stages have vegetation dominated by lodgepole pine, Rocky Mountain Douglas-fir, soopolallie, pine grass and kinnikinnick, while the climax vegetation is dominated by Engelmann spruce, alpine fir and moss.

Opening of the tree canopy, particularly in mature forests (LD5, LD6), creates better understory growth.

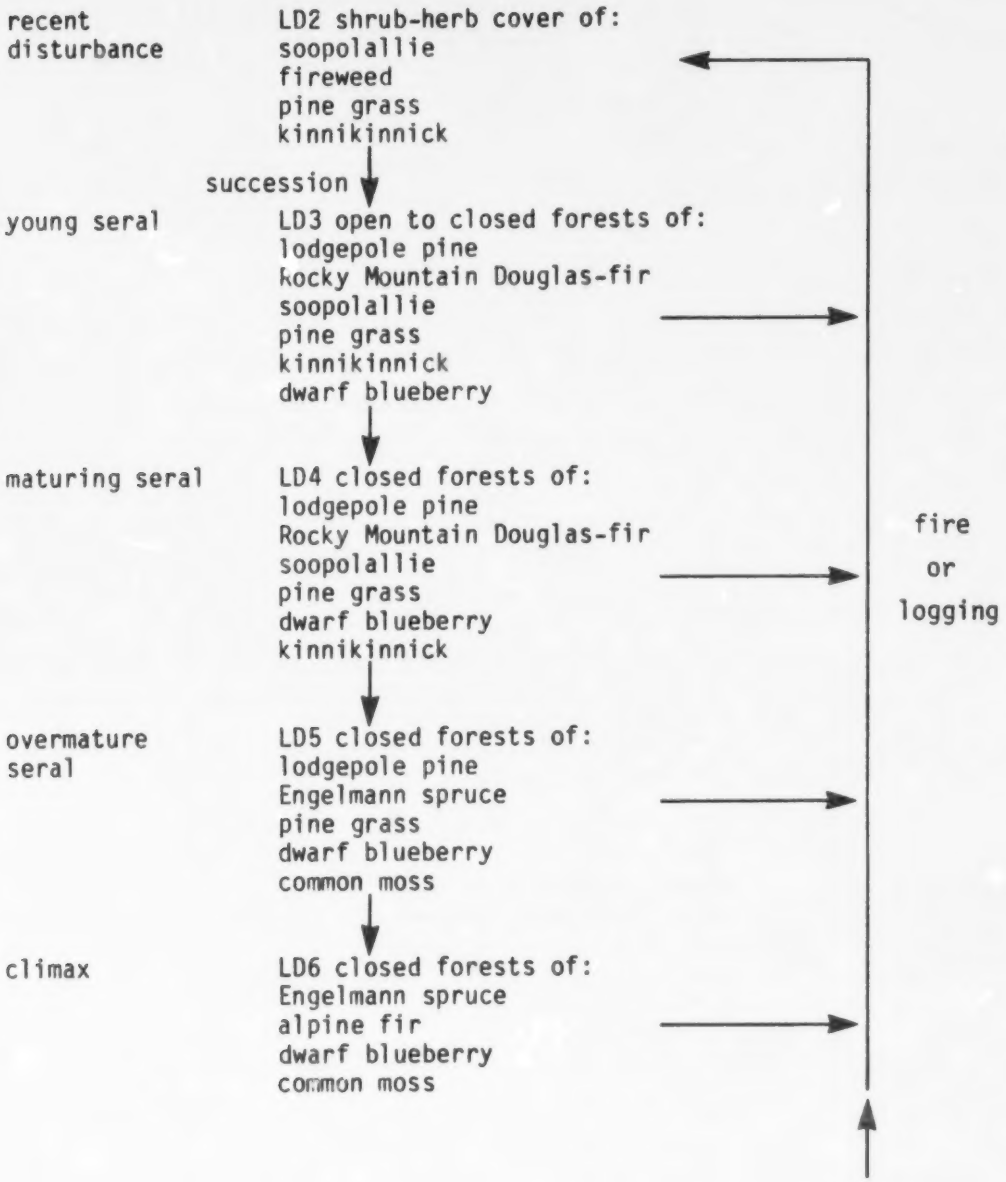

Figure 4.19 Successional trends of the Lodgepole pine - Rocky Mountain Douglas-fir vegetation landscape (LD)

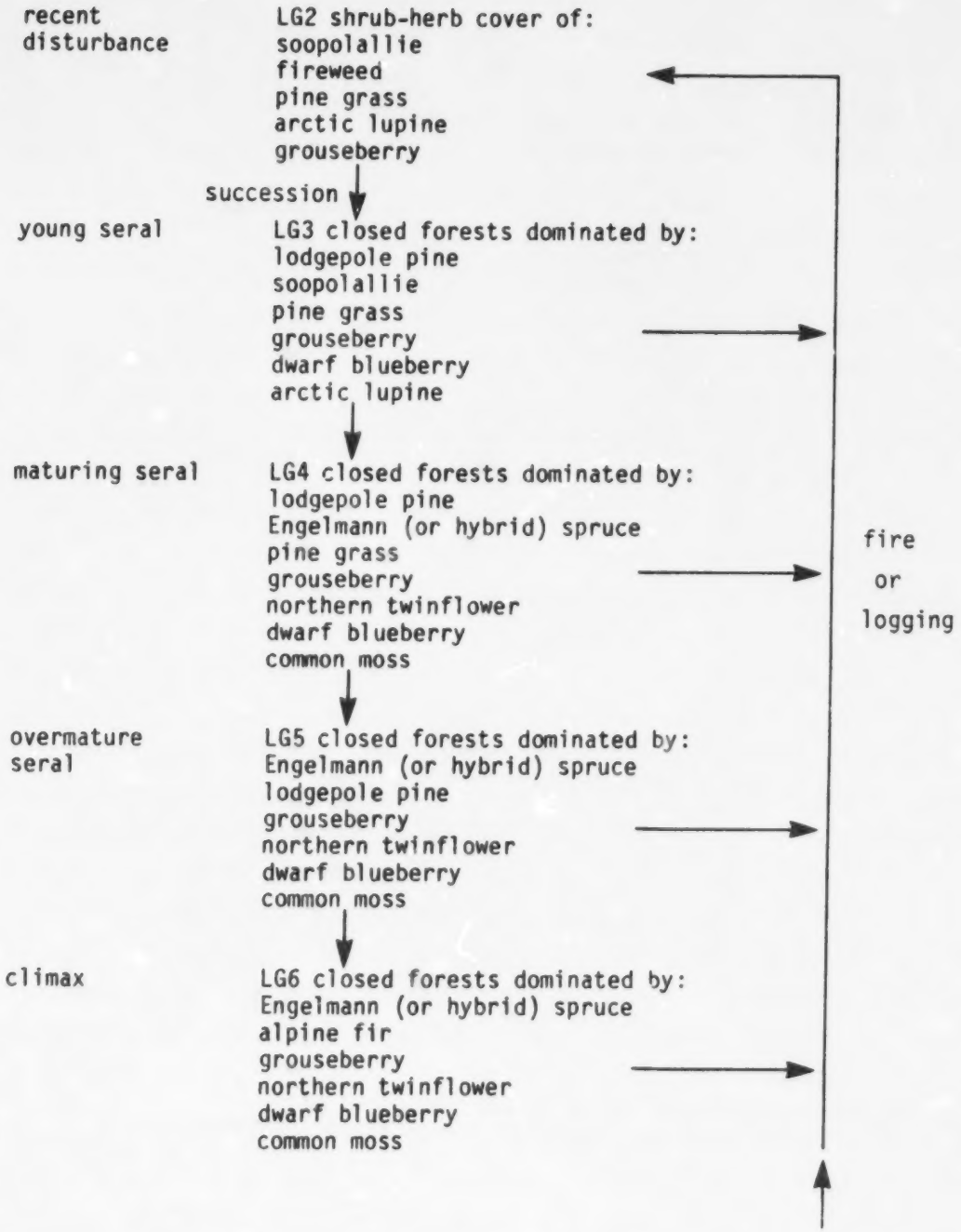

Figure 4.20 Successional trends of the Lodgepole pine - grouseberry vegetation landscape (LG)

Lodgepole pine - grouseberry vegetation landscape (LG)
(see Figure 4.20)

The vegetation of this landscape succeeds from a shrub-herb cover (LG2) to closed, coniferous forests with sparse shrubs and herbs but abundant moss cover (LG6). This landscape is generally found on gently sloping areas with deep, well to moderately well drained soils of morainal material within the Rocky Mountain Douglas-fir - lodgepole pine subzone of the Subalpine Engelmann spruce - alpine fir zone. Moisture availability is average for this subzone as is the rate of succession. The soils associated with the landscape are Brunisolic Gray Luvisols, Podzolic Gray Luvisols and Humo-Ferric Podzols.

After disturbance to the forested stages a cover dominated by fireweed, pine grass and American red raspberry establishes. Alder and willow may become dominant, particularly on moister areas. Seral forests are dominated by lodgepole pine, grouseberry and pine grass while the climax forest is dominated by Engelmann spruce (or hybid spruce at lower elevations), alpine fir, grouseberry, dwarf blueberry and common moss.

Opening of the tree canopy, particularly in mature forests (LG5, LG6), creates better understory production.

Lodgepole pine - arctic lupine vegetation landscape (LL)
(see Figure 4.21)

The vegetation of this landscape succeeds from a herb dominated cover (LL2) to closed forests with a sparse shrub-herb understory but a continuous moss cover. This landscape generally occurs on gently sloping, droughty sites, with shallow or morainal material or deep fluvial material, within the Rocky Mountain Douglas-fir -lodgepole pine subzone of the Subalpine Engelmann spruce - alpine fir zone. These sites usually have well to rapidly drained soils.

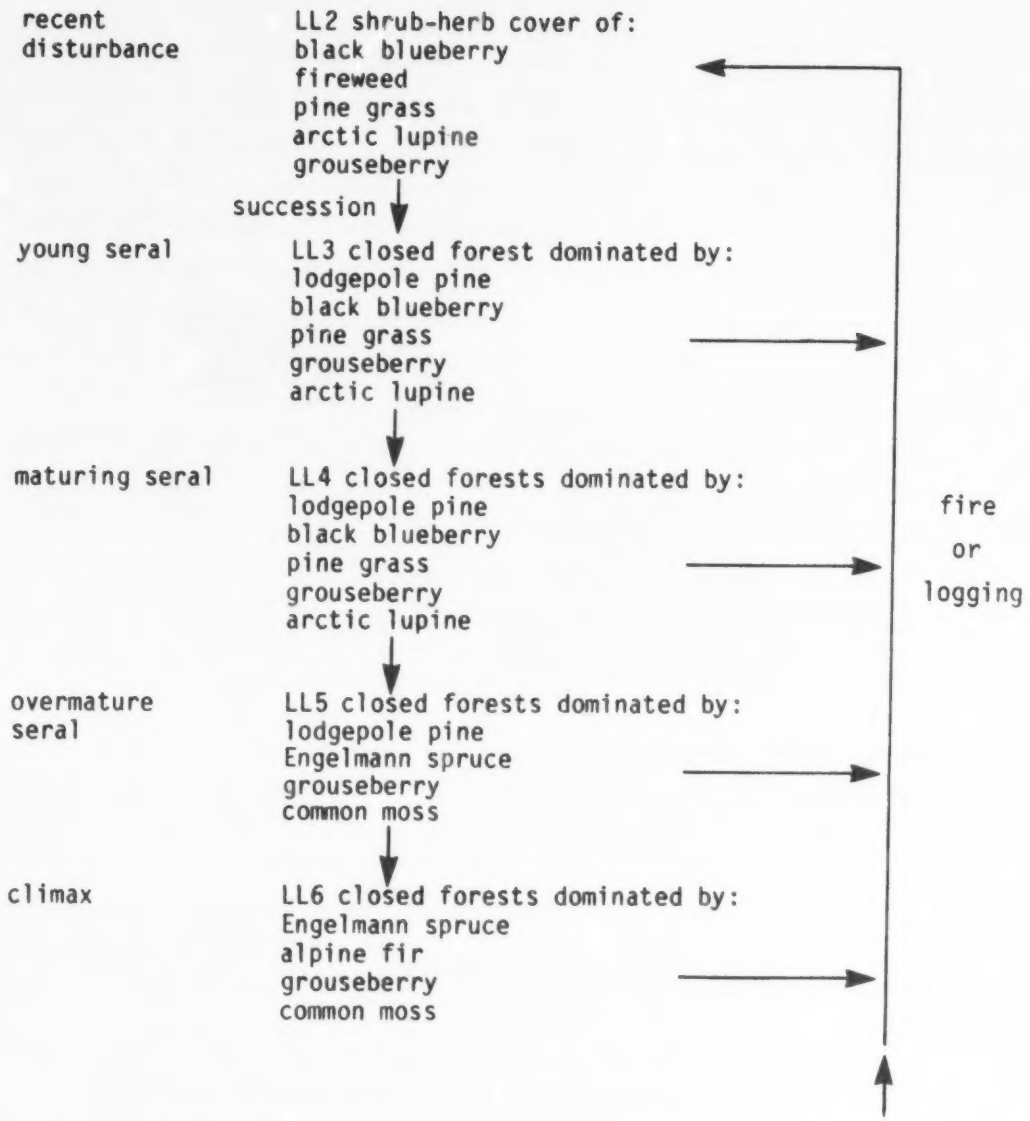

Figure 4.21 Successional trends of the Lodgepole pine - arctic lupine vegetation landscape (LL)

The rate of succession is relatively slow for this subzone. The soils are Orthic Humo-Ferric Podzols and Podzolic Gray Luvisols.

After disturbance, a cover dominated by black blueberry, fireweed, pine grass and arctic lupine establishes. Seral forests are dominated by lodgepole pine, black blueberry, pine grass and arctic lupine while climax forests are dominated by Engelmann spruce, alpine fir, grouseberry and common moss.

Opening the tree canopy, particularly in mature forests (LL5, LL6), creates better understory production.

Sedge - glandular birch vegetation landscape (SB)

The vegetation of this landscape is dominated by sedges, glandular birch, willow and bluejoint small reed grass.

This landscape is common in depressional areas which have high water tables for much of the year. Mineral rich groundwater seeps into these areas from the surrounding slopes. The herbaceous vegetation of these fens is growing in organic soil materials although the shrubs may be rooted in mineral soil.

4.4.5 ENVIRONMENTAL REQUIREMENTS OF SELECTED FORAGE SPECIES

The following information will permit the habitat manager to determine which of the desirable forage species (selected from Appendix C) may be suited for propagation on a given site, by comparing the characteristics of the site with the requirements of each of the species.

For selected forage species, the environmental requirements, suitable map units, propagation methods and required manipulation to achieve a cover of a species, are described. Information on these items was extracted from a variety of sources. The references are acknowledged at the bottom of each table and more detailed information can be retrieved from these.

SPECIES: big sagebrush (Artemisia tridentata)

ENVIRONMENTAL REQUIREMENTS

- prefers deep, nutrient rich, well drained soils
- restricted to warm climatic area of lower elevations
- to dominate areas it requires little competition from grasses
- shade intolerant

LOCATION IN STUDY AREA

- abundant throughout Interior bunch grass zone and lower areas of the Ponderosa pine subzone of the Interior Rocky Mountain Douglas-fir zone.

SUITABLE MAP UNITS

Abundant	WS1; NS1; RW1; PS1; SS1
Moderate	NS2,6; WS2,6; SS2,6; PS2

REQUIRED MANIPULATION

- minimize competition from grasses
- in lower elevations of Rocky Mountain Douglas-fir zone need to remove tree cover and grass cover to induce big sagebrush to occur
- can be removed by fire, herbicides or mechanical methods and subsequent establishment of a competitive cover

PROPAGATION

- seed stratification unnecessary but does improve germination (10 days at 2°C with moisture)
- collect seed in fall or early winter
- seed germinates naturally at relatively cool temperatures
- sow in late fall or winter
- seed spread by wind

REFERENCES

Intermountian Forest and Range Experiment Station (no date); Sturges (1977); Daubenmire (1952); U.S. Department of Agriculture, Forest Service (1974)

SPECIES: bluebunch wheat grass (Agropyron spicatum)	
ENVIRONMENTAL REQUIREMENTS	
- poor winter hardiness - confined to lower elevations - tolerant of fairly droughty conditions - generally on deep, well to rapidly drained soils - tolerant of various soil textures - more tolerant of calcareous than acid conditions - tolerant of low nutrient levels - slightly shade tolerant - low grazing tolerance	
LOCATION IN STUDY AREA	
- within study area common throughout lower elevations and medium elevation on southern exposures	
SUITABLE MAP UNITS	
Abundant	WS2,6; NS2,6; RW1; PJ6; SS2,6: PW1-4; PS2-6; PR1-6; DW1,2,3
Moderate	WS1; NS1; SS1; PW5; PS1; DW4
REQUIRED MANIPULATION	
- restrict grazing and limit competition to allow recovery in grazed areas or graze in autumn - do not graze late spring when the late sheath and head are emerging as reserve carbohydrates are at lowest point and regrowth will not occur - burning reduces yield first year after burning but increases subsequently - graze in early spring and late fall; spring use should not excced 30% - remove big sagebrush to greatly increase productivity remove dead stems and leaves to allow ungulates to get to new growth early in the growing season (by burning or fall grazing)	
PROPAGATION	
- establishment by natural reseeding is moderate, vegetative reproduction is poor - fall seeding preferred unless seedbeds prepared in which case spring seeding can occur - natural germination usually occurs in the fall but may occur in the spring	
REFERENCES	
Watson et al. (1980); Tisdale and Hironaka (1981); Mueggler and Stewart (1980); McLean (1979); Willms et al. (1980); McLean and Tisdale (1972).	

SPECIES: choke cherry (Prunus virginiana)	
ENVIRONMENTAL REQUIREMENTS	
- relatively intolerant of shade - prefers open dry sites - deep, well to rapidly drained soils - fairly drought tolerant	
LOCATION IN STUDY AREA	
- on dry south facing slopes at lower elevations in the study area; not common	
SUITABLE MAP UNITS	
Abundant	
Moderate	SC1, PR1-3
REQUIRED MANIPULATION	
- paritial or total removal of tree cover	
PROPAGATION	
- collect fruit when fully mature; clean the seed of all pulp and juice; requires cold stratification in a moist medium for 120-160 days (5°C) - sow early in spring or early fall - also root cuttings - sprouts from roots often browsing	
REFERENCES	
U.S. Department of Agriculture, Forests Service (1974); Watston et al. (1980)	

SPECIES: common saskatoon (Amelanchier alnifolia)

ENVIRONMENTAL REQUIREMENTS

- wide range of soils
- generally on shallow to deep, well drained soils within the Interior Rocky Mountain Douglas-fir zone
- occurs commonly on talus slopes,
- part shade during the first year is beneficial
- seedlings are drought tolerant
- fairly shade tolerant although it prefers open sites

LOCATION IN STUDY AREA

- widespread throughout Interior Douglas-fir zone and rare in Interior bunch grass zone on talus slopes

SUITABLE MAP UNITS

Abundant	PC2; DC2; SC1
Moderate	PC3, DC3, PW2, 3; PR2, 3; DJ5; DW1, 2,; PJ6; BM1

REQUIRED MANIPULATION

- opening of forest stands by cutting or fire will allow new plants to grow and allow better production in established plants

PROPAGATION

- seed may be sown in the fall or stratified (2-5°C for 180 days) and sown in the spring
- grafting, cutting, layering and bare-root stock are possible methods of establishment
- fire may destroy aerial portions - but root sprouting may occur
- seed dispersal by birds and animals

REFERENCES

Tisdale and Hironaka,(1981); U.S. Department of Agriculture, Forest Service, (1974); Watson et al. (1980)

SPECIES: Oregon boxwood (Paxistima myrsinites)

ENVIRONMENTAL REQUIREMENTS

- deep well drained soils
- areas with slightly higher precipitation
- shade tolerant

LOCATION IN STUDY AREA

- limited in extent to upper areas of Interior Rocky Mountain Doulgas-fir zone and lower areas of Subalpine Engelmann spruce - alpine fir zone particularly in the Watching Creek area

SUITABLE MAP UNITS

Abundant	-
Moderate	LP2-6, LG2-6

REQUIRED MANIPULATION

- unknown

PROPAGATION

- softwood cuttings best

REFERENCES

Carr and Marchant (1982); Kruckeburg (1982)

SPECIES: Oregon grape (Mahonia repens)

ENVIRONMENTAL REQUIREMENTS

- mainly on deep well-drained soils
- fairly shade tolerant
- moderately drought tolerant

LOCATION IN STUDY AREA

- uncommon in forested areas at moderate elevations

SUITABLE MAP UNITS

Abundant	-
Moderate	LP3-6, PW3-6, AP3-6, SC1

REQUIRED MANIPULATION

- unknown

PROPAGATION

- best grown from seeds; cold stratification required
- cleaned seed may be sown in the fall
- cuttings, taken in the fall root best

REFERENCES

Kruckeburg (1982); U.S. Department of Agriculture, Forest Service (1974)

SPECIES: paper birch (Betula papyrifera)

ENVIRONMENTAL REQUIREMENTS

- requires nutrient rich, moist, moderately well to well drained soil conditions such as on floodplain areas and receiving slope positions (within study area)
- variety of soil textures
- best germination and early survival occur where mineral soil has been exposed and where there is some shade
- growth is better without shade after initial establishment

LOCATION IN STUDY AREA

- in moister, cooler sites within the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone

SUITABLE MAP UNITS

Abundant	CS2-4; BA2-4
Moderate	LS2, 3

REQUIRED MANIPULATION

- clear or burn areas in years of good seed production leaving seed trees nearby; retain humus but expose mineral soil if planting

PROPAGATION

- good germination and survival occur where moisture is high
- higher proportion of seed is viable in good seed years
- seed should be sown soon after collection in late summer or fall
- will often resprout from base of the trunk after fire or browsing
- propagates from suckers
- container seedlings, layering, cuttings, budding and grafting are practical

REFERENCES

Marquis (1969); U.S. Department of Agriculture, Forest Service (1974); Watson et al. (1980)

SPECIES: prairie koeleria (june grass)(Koeleria macrantha)

ENVIRONMENTAL REQUIREMENTS

- well drained to rapidly drained soils, medium to coarse texture
- tolerant of drought
- grows best on neutral soils, also found on alkaline soils
- tolerant of low fertility
- tolerant of some shade
- moderate tolerance to grazing
- may invade disturbed sites

LOCATION IN STUDY AREA

- low elevation grasslands and open forests

SUITABLE MAP UNITS

Abundant	NS2,6; WS2,6; SS2,6; PS1,2,6
Moderate	NS1, WS1, SS1, RW1, PW2, PS3-6; PR1,2

REQUIRED MANIPULATION

- may increase after fire
- increases when grazing removed from sites of poor to fair range condition

PROPAGATION

- propagates itself by seed
- moisten seeds with potassium nitrate (0.2 percent at 20°C for 16 hr.) or warm (30°C for 8 hr.)

REFERENCES

Johnson and Strang (1981); Watson et al. (1980)

SPECIES: prairie sagebrush (Artemisia frigida)

ENVIRONMENTAL REQUIREMENTS

- tolerant of droughty conditions
- deep or shallow, well to rapidly drained soils
- prefers open areas, does not seem to tolerate shade
- medium to coarse textured soils
- present in climax grasslands
- may invade disturbed sites or pioneer on rocky sites

LOCATION IN STUDY AREA

- fairly common in low elevation grasslands as well as being present in open forests and rocky areas

SUITABLE MAP UNITS

Abundant	-
Moderate	WS1,2,6; NS1,2,6; SS1,6

REQUIRED MANIPULATION

- in areas that are overgrazed remove grazing to allow its recovery in the earlier stages
- will be greatly reduced in amounts in later stages of succession

PROPAGATION

- spreads naturally by seeds
- plant in spring
- seed is viable for two years

REFERENCES

Tisdale (1947); Vories (1981)

SPECIES: red-osier dogwood (Cornus sericea)

ENVIRONMENTAL REQUIREMENTS

- common on river banks and floodplains
- moderately well to poorly drained soils
- does best on well drained soils with adequate soil moisture
- grows on moderately acidic to moderately alkaline soils
- is slightly shade tolerant, prefers open sites
- invades disturbed floodplain sites, pioneers on recent sites

LOCATION IN STUDY AREA

- wetter locations: floodplains, small creeks, depressional areas throughout study areas, but avoids stagnant water

SUITABLE MAP UNITS

Abundant	CS2-4
Moderate	BM1; AS2-4; BA2-4; CS5, 6

REQUIRED MANIPULATION

- opening the forest canopy particularly in dense or coniferous dominated stands,
- seeding may be done on suitable sites

PROPAGATION

- spreads by root sprouts after it has been established
- seed is best sown in the fall
- seed requires stratification (2°-5°C for 60-90 days)
- also hardwood cuttings, softwood cuttings, stem cuttings and root cuttings
- natural seed dispersal by birds and animals

REFERENCES

Watson et al. (1980); U.S. Department of Agriculture, Forest Service (1964)

SPECIES: redstem ceanothus (Ceanothus sanguineus)

ENVIRONMENTAL REQUIREMENTS

- intolerant of shade; grows best in early successional stages
- requires fires for natural germination
- requires relatively moist conditions in the Interior Rocky Mountain Douglas-fir zone
- generally on deep, well drained soils
- symbiotic root nodules increase soil nitrogen and may allow it to grow on nutrient-poor sites

LOCATION IN STUDY AREA

- within Lodgepole pine subzone of Interior Rocky Mountain Douglas-fir zone west of Tranquille River, north of Hardie Hill

SUITABLE MAP UNITS

Abundant	DC2
Moderate	DC3

REQUIRED MANIPULATION

- spring and fall prescribed burns are successful in providing heat necessary to induce germination of seeds; fall burn may be preferred as fire is hotter and seeds may germinate the following spring
- appears to establish well on mineral substrate

PROPAGATON

- seed germination requires heating (optimum 100°C) and cold stratification
- seed remains dormant but viable in the soil for many years
- for artificially induced germination - use hot water treatment (85°C for 5 - 10 minutes) followed by stratification (90 days) or can sow the seeds in late fall after heat treatment
- will resprout root crowns following fire or browsing

REFERENCES

Orme and Leege (1976); Gratkowski (1973); U.S. Department of Agriculture, Forest Service (1974)

SPECIES: Rocky Mountain maple (Acer glabrum)

ENVIRONMENTAL REQUIREMENTS

- fairly tolerant of shade but seems to prefer partial shade
- prefers moist sits although is fairly drought tolerant
- usually on well drained soils

LOCATION IN STUDY AREA

- moist, cool locations at moderate elevations throughout the study area; common in gulleys; may also be found on dry slopes

SUITABLE MAP UNITS

Abundant	BM1, DJ2-5, DM2-3
Moderate	PH2-5, DM4-6, DW2-4, CS2-6, PC2-3

REQUIRED MANIPULATION

- thinning of tree cover
- fire will remove decadent shrubs and promote resprouting

PROPAGATON

- by seed sown soon after fall harvest or alternating with warm-cold stratification of 30 to 60 days at 20° to 30°C then for go to 180° at 3°C
- sprouts from roots after fires or browsing

REFERENCES

Kruckeberg (1982); U.S Department of Agriculture, Forest Service (1974)

SPECIES: rough fescue (Festuca scabrella)

ENVIRONMENTAL REQUIREMENTS

- requires shade in drier environments such as the Interior bunch grass zone but grows as a grassland component in moister areas at higher elevations
- low tolerance to grazing
- moderately tolerant to drought

LOCATION IN STUDY AREA

- dry forested areas within the Interior Rocky Mountain Douglas-fir zone and moister grassland areas

SUITABLE MAP UNITS

Abundant	PF2-6
Moderate	PW3-6; PS3-6, DS6, DW2-6

REQUIRED MANIPULATION

- in sites where rough fescue is overgrazed control grazing to allow recovery
- graze in early spring or late fall

PROPAGATION

- spreads naturally by seeds

REFERENCES

McLean and Tisdale (1972)

SPECIES: Sandberg's blue grass (Poa sandbergii)	
ENVIRONMENTAL REQUIREMENTS	
- confined to lower elevations - tolerant of drought - on shallow to deep, well drained soils - low tolerance to shade - found on alkaline soils - frequently on coarser soils - neutral to calcareous soils - commonly has regrowth in fall and begins growth when snow melts in spring	
LOCATION IN STUDY AREA	
- common throughout lower elevations	
SUITABLE MAP UNITS	
Abundant	WS1; NS1; SS1; PS1; RW1
Moderate	WS2, 6; NS2, 6; SS2, 6; PS2, 3
REQUIRED MANIPULATION	
- unknown	
PROPAGATION	
- seed	
REFERENCES	
Mueggler and Stewart (1980); McLean and Tisdale (1972); Willms et al. (1975); Tisdale and Hironaka (1981); Tisdale (1947)	

SPECIES: shrubby penstemon (Penstemon fruticosus)

ENVIRONMENTAL REQUIREMENTS

- frequently found on dry areas with shallow soil or on bedrock and at the top of knolls
- tolerant of droughty conditions
- shade intolerant

LOCATION IN STUDY AREA

- generally on drier sites within the Interior Rocky Mountain Douglas-fir zone

SUITABLE MAP UNITS

Abundant	PR1, 2
Moderate	RW1, 2; PR3, 4; DW1, 2

REQUIRED MANIPULATION

- planting may be the only way to increase this species

PROPAGATION

- propagates easily by cuttings
- seeds and germinates readily in hot, sandy or gravelly location

REFERENCES

Clark (1973); Kruckeberg (1982)

SPECIES: smooth sumac (Rhus glabra)	
ENVIRONMENTAL REQUIREMENTS	
- tolerant of dry, coarse textured soils in open areas - does best in moister sites at base of slopes	
LOCATION IN STUDY AREA	
- rare on slopes and at the base of slopes within the Interior bunch grass zone	
SUITABLE MAP UNITS	
Abundant	
Moderate	NS1, 2, 6; SC1
REQUIRED MANIPULATION	
- planting may be the only way to increase this species, although suckering may occur after fire or mechanical damage	
PROPAGATION	
- suckers freely from underground rootstock - seed requires scarification with either hot water or sulphuric acid - sow in the fall or spring - 2 cm deep - also from root cuttings	
REFERENCES	
U.S. Department of Agriculture, Forest Service, (1974); Vories (1981)	

SPECIES: snowbush ceanothus (Ceanothus velutinus)

ENVIRONMENTAL REQUIREMENTS

- shade intolerant; grows best in early successional stages
- requires fires for natural germination due to a hard, impermeable seed coat
- generally on deep, well drained soils
- requires relatively moist conditions in the Ponderosa pine subzone of the Interior Rocky Mountain Douglas-fir zone
- symbiotic root nodules fix atmospheric nitrogen, increase soil nitrogen and gives it a competitive advantage to grow on infertile sites
- moderately acid to neutral soil

LOCATION IN STUDY AREA

- north side of Tranquille River within the Ponderosa pine subzone of the Interior Rocky mountain Douglas-fir zone

SUITABLE MAP UNITS

Abundant	PC2
Moderate	PC3
Rare	DW2-4

REQUIRED MANIPULATION

- spring and fall prescribed burns are successful in breaking dormancy for the seeds to germinate; fall burn may be preferred as fire is hotter and seeds are ready to germinate the following spring

PROPAGATION

- seed germination requires heating and cold stratification
- may spread by vegetative regeneration
- seed remains dormant but viable in the soil for many years (up to 100 yr)
- for artificially induced germination - use hot water treatment (100°C for 5 min) followed by stratification (90 days)
- can be grown from bare-rootstock, containerized transplants or rooted cuttings
- will resprout from root crowns after fire or browsing

REFERENCES

Gratkowski (1973); Intermountain Forest and Range Experiment Station (no date); U.S. Department of Agriculture, Forest Service (1974); Watson et al (1980); Franklin and Dyrness (1973)

SPECIES: willows - upland (includes Scouler's willow and others) (Salix spp.)

ENVIRONMENTAL REQUIREMENTS

- generally of deep, well to moderately well drained soils
- moist to wet conditions within the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone and in the Subalpine Engelmann spruce - alpine fir zone
- generally shade intolerant
- wide range of soil textures
- rapidly invades burned areas, logged areas and roadsides

LOCATION IN STUDY AREA

- common but not abundant in open forested areas throughout the Lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone and the Subalpine Engelmann spruce - alpine fir zone

SUITABLE MAP UNITS

Abundant	PC2, DC2
Moderate	PC3; LP2, 3; DC3, 4; LG2, 3

REQUIRED MANIPULATION

- more common and productive in early stages of succession so that fire or clearing encourages their growth
- decadent plants will resprout after fire or pruning

PROPAGATION

- seed must be collected as soon as the fruits ripen and planted soon after; short period of viability
- sprouts well from branches that have been browsed
- also hardwood cuttings, softwood cuttings, seedlings, transplants
- cutting leads to basal sprouting, while fire further promotes basal sprouting

REFERENCES

U.S. Department of Agriculture, Forest Service (1974); Watson et al. (1980); Vories (1981)

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APPENDIX A
CLIMATE

Estimated average monthly precipitation, potential evapotranspiration and climatic moisture deficit as a function of slope, aspect, elevation and time of year.

TABLE A.1a

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of May at an Elevation of 400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	18	18	18	18	18	18
	PET	113	104	90	73	54	33
	CMB	-95	-86	-72	-55	-36	-15
SOUTH	PPT	18	18	18	18	18	18
	PET	113	120	122	120	115	106
	CMB	-95	-102	-104	-102	-97	-88
NE/NW	PPT	18	18	18	18	18	18
	PET	113	107	97	84	70	56
	CMB	-95	-89	-79	-66	-52	-38
SE/SW	PPT	18	18	18	18	18	18
	PET	113	119	120	120	115	107
	CMB	-95	-101	-102	-102	-97	-89
E/W	PPT	18	18	18	18	18	18
	PET	113	113	111	106	99	90
	CMB	-95	-95	-93	-88	-81	-72

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.1b

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of June at an Elevation of 400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	33	33	33	33	33	33
	PET	135	128	116	101	83	61
	CMB	-102	-95	-83	-68	-50	-28
SOUTH	PPT	33	33	33	33	33	33
	PET	135	139	138	133	125	112
	CMB	-102	-106	-105	-100	-92	-79
NE/NW	PPT	33	33	33	33	33	33
	PET	135	131	122	109	94	78
	CMB	-102	-98	-89	-76	-61	-45
SE/SW	PPT	33	33	33	33	33	33
	PET	135	139	138	135	128	117
	CMB	-102	-106	-105	-102	-95	-84
E/W	PPT	33	33	33	33	33	33
	PET	135	135	131	126	117	107
	CMB	-102	-102	-98	-93	-84	-74

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.1c

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of July at an Elevation of 400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	24	24	24	24	24	24
	PET	149	138	122	102	79	52
	CMB	-125	-114	-98	-78	-55	-28
SOUTH	PPT	24	24	24	24	24	24
	PET	149	155	156	151	143	130
	CMB	-125	-131	-132	-127	-119	-106
NE/NW	PPT	24	24	24	24	24	24
	PET	149	143	130	115	97	79
	CMB	-125	-116	-106	-91	-73	-55
SE/SW	PPT	24	24	24	24	24	24
	PET	149	153	155	153	146	135
	CMB	-125	-129	-131	-129	-122	-111
E/W	PPT	24	24	24	24	24	24
	PET	149	149	146	139	130	120
	CMB	-125	-125	-122	-115	-106	-96

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.1d

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of August at an Elevation of 400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	25	25	25	25	25	25
	PET	116	101	83	61	37	11
	CMB	-91	-76	-58	-36	-12	+14
SOUTH	PPT	25	25	25	25	25	25
	PET	116	127	133	135	132	124
	CMB	-91	-102	-108	-110	-107	-99
NE/NW	PPT	25	25	25	25	25	25
	PET	116	108	96	81	66	52
	CMB	-91	-83	-71	-56	-41	-27
SE/SW	PPT	25	25	25	25	25	25
	PET	116	125	131	133	131	125
	CMB	-91	-100	-106	-108	-106	-100
E/W	PPT	25	25	25	25	25	25
	PET	116	117	117	113	108	99
	CMB	-91	-92	-92	-88	-83	-74

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.1e

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of September at an Elevation of 400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	19	19	19	19	19	19
	PET	63	47	29	9	0	0
	CMB	-44	-28	-10	+10	+19	+19
SOUTH	PPT	19	19	19	19	19	19
	PET	63	77	87	95	99	98
	CMB	-44	-58	-68	-76	-80	-79
NE/NW	PPT	19	19	19	19	19	19
	PET	63	53	41	29	18	9
	CMB	-44	-34	-22	-10	+1	+10
SE/SW	PPT	19	19	19	19	19	19
	PET	63	74	82	87	90	88
	CMB	-44	-55	-63	-68	-71	-69
E/W	PPT	19	19	19	19	19	19
	PET	63	65	63	62	58	54
	CMB	-44	-46	-44	-43	-39	-35

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.2a

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of May at an Elevation of 600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	22	22	22	22	22	22
	PET	110	100	87	71	52	31
	CMB	-88	-78	-65	-49	-30	-9
SOUTH	PPT	22	22	22	22	22	22
	PET	110	116	118	117	111	102
	CMB	-88	-94	-96	-95	-89	-80
NE/NW	PPT	22	22	22	22	22	22
	PET	110	104	94	81	68	54
	CMB	-88	-82	-72	-59	-46	-32
SE/SW	PPT	22	22	22	22	22	22
	PET	110	115	117	116	111	104
	CMB	-88	-93	-95	-94	-89	-82
E/W	PPT	22	22	22	22	22	22
	PET	110	110	108	102	96	87
	CMB	-88	-88	-86	-80	-74	-65

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.2b

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of June at an Elevation of 600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	37	37	37	37	37	37
	PET	133	125	114	99	81	60
	CMB	-96	-88	-77	-62	-44	-23
SOUTH	PPT	37	37	37	37	37	37
	PET	133	137	136	131	123	111
	CMB	-96	-100	-99	-94	-86	-74
NE/NW	PPT	37	37	37	37	37	37
	PET	133	128	120	107	92	77
	CMB	-96	-91	-83	-70	-55	-40
SE/SW	PPT	37	37	37	37	37	37
	PET	133	137	136	132	125	115
	CMB	-96	-100	-99	-95	-88	-78
E/W	PPT	37	37	37	37	37	37
	PET	133	133	129	124	115	106
	CMB	-96	-96	-92	-87	-78	-69

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.2c

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of July at an Elevation of 600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	28	28	28	28	28	28
	PET	145	134	119	99	77	50
	CMB	-117	-106	-91	-71	-49	-22
SOUTH	PPT	28	28	28	28	28	28
	PET	145	151	151	147	139	126
	CMB	-117	-123	-123	-119	-111	-98
NE/NW	PPT	28	28	28	28	28	28
	PET	145	139	127	112	95	77
	CMB	-117	-111	-99	-84	-67	-49
SE/SW	PPT	28	28	28	28	28	28
	PET	145	150	151	149	142	132
	CMB	-117	-122	-123	-121	-114	-104
E/W	PPT	28	28	28	28	28	28
	PET	145	145	142	135	127	116
	CMB	-117	-117	-114	-107	-99	-88

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.2d

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of August at an Elevation of 600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	31	31	31	31	31	31
	PET	112	98	80	59	36	10
	CMB	-81	-67	-49	-28	-5	+21
SOUTH	PPT	31	31	31	31	31	31
	PET	112	123	129	131	128	121
	CMB	-81	-92	-98	-100	-97	-90
NE/NW	PPT	31	31	31	31	31	31
	PET	112	105	93	78	63	76
	CMB	-81	-74	-62	-47	-32	-45
SE/SW	PPT	31	31	31	31	31	31
	PET	112	122	127	130	127	122
	CMB	-81	-91	-96	-99	-96	-91
E/W	PPT	31	31	31	31	31	31
	PET	112	114	113	110	105	96
	CMB	-81	-83	-82	-79	-74	-65

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.2e

Estimated Average Monthly Precipitation (PPT[1] mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of September at an Elevation of 600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	23	23	23	23	23	23
	PET	61	46	27	8	0	0
	CMB	-38	-23	-4	+15	+23	+23
SOUTH	PPT	23	23	23	23	23	23
	PET	61	74	84	92	95	95
	CMB	-38	-51	-61	-69	-72	-72
NE/NW	PPT	23	23	23	23	23	23
	PET	61	51	40	27	17	8
	CMB	-38	-28	-17	-4	+6	+15
SE/SW	PPT	23	23	23	23	23	23
	PET	61	71	79	84	87	85
	CMB	-38	-48	-56	-61	-64	-62
E/W	PPT	23	23	23	23	23	23
	PET	61	62	61	59	56	52
	CMB	-38	-39	-38	-36	-33	-29

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.3a

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of May at an Elevation of 800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	26	26	26	26	26	26
	PET	106	96	84	68	50	29
	CMB	-80	-70	-58	-42	-24	-3
SOUTH	PPT	26	26	26	26	26	26
	PET	106	111	114	112	107	98
	CMB	-80	-85	-88	-86	-81	-72
NE/NW	PPT	26	26	26	26	26	26
	PET	106	100	90	78	65	52
	CMB	-80	-74	-64	-52	-39	-26
SE/SW	PPT	26	26	26	26	26	26
	PET	106	111	112	111	107	100
	CMB	-80	-85	-86	-85	-81	-74
E/W	PPT	26	26	26	26	26	26
	PET	106	106	104	98	92	84
	CMB	-80	-80	-78	-72	-66	-58

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.3b

Estimated Average Monthly Precipitation (PPT[1] mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of June at an Elevation of 800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	41	41	41	41	41	41
	PET	129	121	110	96	78	58
	CMB	-88	-80	-69	-55	-37	-17
SOUTH	PPT	41	41	41	41	41	41
	PET	129	132	131	127	119	107
	CMB	-88	-91	-90	-86	-78	-66
NE/NW	PPT	41	41	41	41	41	41
	PET	129	125	116	104	89	74
	CMB	-88	-84	-75	-63	-48	-33
SE/SW	PPT	41	41	41	41	41	41
	PET	129	132	131	128	121	111
	CMB	-88	-91	-90	-87	-80	-70
E/W	PPT	41	41	41	41	41	41
	PET	129	129	125	120	111	102
	CMB	-88	-88	-84	-79	-70	-61

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.3c

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of July at an Elevation of 800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	32	32	32	32	32	32
	PET	140	130	115	96	74	46
	CMB	-108	-98	-83	-64	-42	-14
SOUTH	PPT	32	32	32	32	32	32
	PET	140	146	147	143	135	122
	CMB	-108	-114	-115	-111	-103	-90
NE/NW	PPT	32	32	32	32	32	32
	PET	140	135	123	109	92	74
	CMB	-108	-103	-91	-77	-60	-42
SE/SW	PPT	32	32	32	32	32	32
	PET	140	145	147	145	138	128
	CMB	-108	-113	-115	-113	-106	-96
E/W	PPT	32	32	32	32	32	32
	PET	140	140	138	131	123	113
	CMB	-108	-108	-106	-99	-91	-81

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.3d

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of August at an Elevation of 800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	37	37	37	37	37	37
	PET	109	95	78	57	34	9
	CMB	-72	-58	-41	-20	+3	+28
SOUTH	PPT	37	37	37	37	37	37
	PET	109	120	126	127	125	117
	CMB	-72	-83	-89	-90	-88	-80
NE/NW	PPT	37	37	37	37	37	37
	PET	109	102	90	76	61	48
	CMB	-72	-65	-53	-39	-24	-11
SE/SW	PPT	37	37	37	37	37	37
	PET	109	118	124	126	124	118
	CMB	-72	-81	-87	-89	-87	-81
E/W	PPT	37	37	37	37	37	37
	PET	109	111	110	106	102	93
	CMB	-72	-74	-73	-69	-65	-56

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.3e

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of September at an Elevation of 800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	28	28	28	28	28	28
	PET	59	44	26	7	0	0
	CMB	-31	-16	+2	+21	+28	+28
SOUTH	PPT	28	28	28	28	28	28
	PET	59	72	82	89	92	92
	CMB	-31	-44	-54	-61	-64	-64
NE/NW	PPT	28	28	28	28	28	28
	PET	59	50	38	26	16	7
	CMB	-31	-22	-10	+2	+12	+21
SE/SW	PPT	28	28	28	28	28	28
	PET	59	69	77	82	84	83
	CMB	-31	-41	-49	-54	-56	-55
E/W	PPT	28	28	28	28	28	28
	PET	59	60	59	57	54	50
	CMB	-31	-32	-31	-29	-26	-22

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.4a

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of May at an Elevation of 1000 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	30	30	30	30	30	30
	PET	102	93	81	65	47	28
	CMB	-72	-63	-51	-35	-17	+2
SOUTH	PPT	30	30	30	30	30	30
	PET	102	108	109	108	103	95
	CMB	-72	-78	-78	-78	-73	-65
NE/NW	PPT	30	30	30	30	30	30
	PET	102	96	87	75	62	50
	CMB	-72	-66	-57	-45	-32	-30
SE/SW	PPT	30	30	30	30	30	30
	PET	102	107	108	108	103	96
	CMB	-72	-77	-78	-78	-73	-66
E/W	PPT	30	30	30	30	30	30
	PET	102	102	100	95	88	81
	CMB	-72	-72	-70	-65	-58	-51

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.4b

Estimated Average Monthly Precipitation (PPT[1] mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of June at an Elevation of 1000 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	44	44	44	44	44	44
	PET	125	117	107	93	75	55
	CMB	-81	-73	-63	-49	-31	-11
SOUTH	PPT	44	44	44	44	44	44
	PET	125	128	127	122	115	103
	CMB	-81	-84	-83	-78	-71	-59
NE/NW	PPT	44	44	44	44	44	44
	PET	125	120	112	100	86	71
	CMB	-81	-76	-68	-56	-42	-27
SE/SW	PPT	44	44	44	44	44	44
	PET	125	128	127	124	117	107
	CMB	-81	-84	-83	-80	-73	-63
E/W	PPT	44	44	44	44	44	44
	PET	125	125	121	116	107	99
	CMB	-81	-81	-77	-72	-63	-55

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.4c

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of July at an Elevation of 1000 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	35	35	35	35	35	35
	PET	136	127	112	93	72	46
	CMB	-101	-92	-77	-58	-37	-11
SOUTH	PPT	35	35	35	35	35	35
	PET	136	142	143	139	131	118
	CMB	-101	-107	-108	-104	-96	-83
NE/NW	PPT	35	35	35	35	35	35
	PET	136	131	120	105	89	72
	CMB	-101	-96	-85	-70	-54	-37
SE/SW	PPT	35	35	35	35	35	35
	PET	136	141	143	140	134	124
	CMB	-101	-106	-108	-105	-99	-89
E/W	PPT	35	35	35	35	35	35
	PET	136	136	134	127	119	109
	CMB	-101	-101	-99	-92	-84	-74

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.4d

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of August at an Elevation of 1000 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	43	43	43	43	43	43
	PET	106	92	75	55	33	8
	CMB	-63	-49	-32	-12	+10	+35
SOUTH	PPT	43	43	43	43	43	43
	PET	106	116	122	124	121	114
	CMB	-63	-73	-79	-81	-78	-71
NE/NW	PPT	43	43	43	43	43	43
	PET	106	99	87	74	59	46
	CMB	-63	-56	-44	-31	-16	-3
SE/SW	PPT	43	43	43	43	43	43
	PET	106	115	120	123	120	115
	CMB	-63	-72	-77	-80	-77	-72
E/W	PPT	43	43	43	43	43	43
	PET	106	108	107	104	99	91
	CMB	-63	-65	-64	-61	-56	-48

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.4e

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of September at an Elevation of 1000 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	32	32	32	32	32	32
	PET	56	42	25	6	0	0
	CMB	-24	-10	+7	+26	+32	+32
SOUTH	PPT	32	32	32	32	32	32
	PET	56	69	79	86	89	89
	CMB	-24	-37	-47	-54	-57	-57
NE/NW	PPT	32	32	32	32	32	32
	PET	56	47	36	25	15	6
	CMB	-24	-15	-4	+7	+17	+26
SE/SW	PPT	32	32	32	32	32	32
	PET	56	66	74	79	81	80
	CMB	-24	-34	-42	-47	-49	-48
E/W	PPT	32	32	32	32	32	32
	PET	56	58	56	55	52	48
	CMB	-24	-26	-24	-23	-20	-16

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.5a

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of May at an Elevation of 1200 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	34	34	34	34	34	34
	PET	98	89	78	63	45	26
	CMB	-64	-55	-44	-29	-11	+8
SOUTH	PPT	34	34	34	34	34	34
	PET	98	104	105	104	99	91
	CMB	-64	-70	-71	-70	-65	-57
NE/NW	PPT	34	34	34	34	34	34
	PET	98	92	84	72	60	47
	CMB	-64	-58	-50	-38	-26	-13
SE/SW	PPT	34	34	34	34	34	34
	PET	98	103	104	104	99	92
	CMB	-64	-69	-70	-70	-65	-58
E/W	PPT	34	34	34	34	34	34
	PET	98	98	96	91	85	78
	CMB	-64	-64	-62	-57	-51	-44

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.5b

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of June at an Elevation of 1200 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	48	48	48	48	48	48
	PET	120	113	103	89	74	53
	CMB	-72	-65	-55	-41	-26	-5
SOUTH	PPT	48	48	48	48	48	48
	PET	120	123	123	118	111	99
	CMB	-72	-75	-75	-70	-63	-51
NE/NW	PPT	48	48	48	48	48	48
	PET	120	116	108	96	83	68
	CMB	-72	-68	-60	-48	-35	-20
SE/SW	PPT	48	48	48	48	48	48
	PET	120	123	123	120	113	104
	CMB	-72	-75	-75	-72	-65	-56
E/W	PPT	48	48	48	48	48	48
	PET	120	120	117	112	104	95
	CMB	-72	-72	-69	-64	-56	-47

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.5c

Estimated Average Monthly Precipitation (PPT[1] mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of July at an Elevation of 1200 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	39	39	39	39	39	39
	PET	132	122	108	90	69	44
	CMB	-93	-83	-69	-51	-30	-5
SOUTH	PPT	39	39	39	39	39	39
	PET	132	137	138	134	126	114
	CMB	-93	-98	-99	-95	-87	-75
NE/NW	PPT	39	39	39	39	39	39
	PET	132	126	116	102	86	69
	CMB	-93	-87	-77	-63	-47	-30
SE/SW	PPT	39	39	39	39	39	39
	PET	132	137	138	136	130	120
	CMB	-93	-98	-99	-97	-91	-81
E/W	PPT	39	39	39	39	39	39
	PET	132	132	130	123	115	105
	CMB	-93	-93	-91	-84	-76	-66

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.5d

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of August at an Elevation of 1200 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	48	48	48	48	48	48
	PET	103	89	73	53	31	47
	CMB	-55	-41	-25	-5	+17	+41
SOUTH	PPT	48	48	48	48	48	48
	PET	103	113	118	120	118	110
	CMB	-55	-65	-70	-72	-70	-62
NE/NW	PPT	48	48	48	48	48	48
	PET	103	96	84	71	57	44
	CMB	-55	-48	-36	-23	-9	+4
SE/SW	PPT	48	48	48	48	48	48
	PET	103	111	117	119	117	111
	CMB	-55	-63	-69	-71	-69	-63
E/W	PPT	48	48	48	48	48	48
	PET	103	104	103	100	96	87
	CMB	-55	-56	-55	-52	-48	-39

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.5e

Estimated Average Monthly Precipitation (PPT[1] mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of September at an Elevation of 1200 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	36	36	36	36	36	36
	PET	54	40	23	6	0	0
	CMB	-18	-4	+13	+30	+36	+36
SOUTH	PPT	36	36	36	36	36	36
	PET	54	67	76	83	86	86
	CMB	-18	-31	-40	-47	-50	-50
NE/NW	PPT	36	36	36	36	36	36
	PET	54	46	35	23	14	6
	CMB	-18	-10	+1	+13	+22	+30
SE/SW	PPT	36	36	36	36	36	36
	PET	54	64	71	76	78	70
	CMB	-18	-28	-35	-40	-42	-41
E/W	PPT	36	36	36	36	36	36
	PET	54	56	54	53	50	46
	CMB	-18	-20	-18	-17	-14	-10

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.6a

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of May at an Elevation of 1400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	38	38	38	38	38	38
	PET	94	86	74	60	43	25
	CMB	-56	-48	-36	-22	-5	+13
SOUTH	PPT	38	38	38	38	38	38
	PET	94	100	101	100	96	87
	CMB	-56	-62	-63	-62	-58	-49
NE/NW	PPT	38	38	38	38	38	38
	PET	94	89	80	69	57	45
	CMB	-56	-51	-42	-31	-19	-7
SE/SW	PPT	38	38	38	38	38	38
	PET	94	99	100	100	96	89
	CMB	-56	-61	-62	-62	-58	-51
E/W	PPT	38	38	38	38	38	38
	PET	94	94	92	87	82	74
	CMB	-56	-56	-54	-49	-44	-36

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.6b

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of June at an Elevation of 1400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	51	51	51	51	51	51
	PET	116	109	99	86	70	51
	CMB	-65	-58	-48	-35	-19	0
SOUTH	PPT	51	51	51	51	51	51
	PET	116	119	118	114	107	96
	CMB	-65	-68	-67	-63	-56	-45
NE/NW	PPT	51	51	51	51	51	51
	PET	116	112	104	93	80	65
	CMB	-65	-61	-53	-42	-29	-14
SE/SW	PPT	51	51	51	51	51	51
	PET	116	119	118	115	109	100
	CMB	-65	-68	-67	-64	-58	-49
E/W	PPT	51	51	51	51	51	51
	PET	116	161	113	108	100	92
	CMB	-65	-65	-62	-57	-49	-41

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.6c

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of July at an Elevation of 1400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	43	43	43	43	43	43
	PET	128	118	105	85	66	42
	CMB	-85	-75	-62	-42	-23	+1
SOUTH	PPT	43	43	43	43	43	43
	PET	128	133	134	130	123	111
	CMB	-85	-90	-91	-87	-80	-68
NE/NW	PPT	43	43	43	43	43	43
	PET	128	123	112	98	83	66
	CMB	-85	-80	-69	-55	-40	-23
SE/SW	PPT	43	43	43	43	43	43
	PET	128	132	134	132	126	116
	CMB	-85	-89	-91	-89	-83	-73
E/W	PPT	43	43	43	43	43	43
	PET	128	127	126	119	111	102
	CMB	-85	-84	-83	-76	-68	-59

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.6d

Estimated Average Monthly Precipitation (PPT[1] mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of August at an Elevation of 1400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	54	54	54	54	54	54
	PET	99	86	70	51	30	7
	CMB	-45	-32	-16	+3	+24	+47
SOUTH	PPT	54	54	54	54	54	54
	PET	99	109	114	117	114	107
	CMB	-45	-55	-60	-63	-60	-53
NE/NW	PPT	54	54	54	54	54	54
	PET	99	92	82	69	55	43
	CMB	-45	-38	-28	-15	-1	+11
SE/SW	PPT	54	54	54	54	54	54
	PET	99	108	113	115	113	108
	CMB	-45	-54	-59	-61	-59	-54
E/W	PPT	54	54	54	54	54	54
	PET	99	100	100	97	92	85
	CMB	-45	-46	-46	-43	-38	-31

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.6e

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of September at an Elevation of 1400 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	40	40	40	40	40	40
	PET	52	38	22	5	0	0
	CMB	-12	+2	+18	+35	+40	+40
SOUTH	PPT	40	40	40	40	40	40
	PET	52	64	73	80	83	82
	CMB	-12	-24	-33	-40	-43	-42
NE/NW	PPT	40	40	40	40	40	40
	PET	52	44	33	22	13	5
	CMB	-12	-4	+7	+18	+27	+35
SE/SW	PPT	40	40	40	40	40	40
	PET	52	61	68	73	75	74
	CMB	-12	-21	-28	-33	-35	-34
E/W	PPT	40	40	40	40	40	40
	PET	52	53	52	51	47	44
	CMB	-12	-13	-12	-11	-7	-4

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.7a

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of May at an Elevation of 1600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	42	42	42	42	42	42
	PET	90	82	71	57	41	23
	CMB	-48	-40	-29	-15	+1	+19
SOUTH	PPT	42	42	42	42	42	42
	PET	90	96	97	96	92	84
	CMB	-48	-54	-55	-54	-50	-42
NE/NW	PPT	42	42	42	42	42	42
	PET	90	85	77	66	55	43
	CMB	-48	-43	-35	-24	-13	-1
SE/SW	PPT	42	42	42	42	42	42
	PET	90	95	96	96	92	85
	CMB	-48	-53	-54	-54	-50	-43
E/W	PPT	42	42	42	42	42	42
	PET	90	90	88	84	78	71
	CMB	-48	-48	-46	-42	-36	-29

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.7b

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of June at an Elevation of 1600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	54	54	54	54	54	54
	PET	112	105	95	82	67	48
	CMB	-58	-51	-41	-28	-13	+6
SOUTH	PPT	54	54	54	54	54	54
	PET	112	114	114	110	103	92
	CMB	-58	-60	-60	-56	-49	-38
NE/NW	PPT	54	54	54	54	54	54
	PET	112	107	100	89	76	63
	CMB	-58	-53	-46	-35	-22	-9
SE/SW	PPT	54	54	54	54	54	54
	PET	112	114	114	111	104	112
	CMB	-58	-60	-60	-57	-51	-58
E/W	PPT	54	54	54	54	54	54
	PET	112	112	108	104	96	88
	CMB	-58	-58	-54	-50	-42	-34

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.7c

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of July at an Elevation of 1600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	46	46	46	46	46	46
	PET	123	114	100	83	64	40
	CMB	-77	-68	-54	-37	-18	+6
SOUTH	PPT	46	46	46	46	46	46
	PET	123	129	129	126	118	107
	CMB	-77	-83	-83	-80	-72	-61
NE/NW	PPT	46	46	46	46	46	46
	PET	123	118	108	95	79	64
	CMB	-77	-72	-62	-49	-33	-18
SE/SW	PPT	46	46	46	46	46	46
	PET	123	128	129	127	121	112
	CMB	-77	-82	-83	-81	-75	-66
E/W	PPT	46	46	46	46	46	46
	PET	123	123	121	115	107	98
	CMB	-77	-77	-75	-69	-61	-52

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.7d

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of August at an Elevation of 1600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	60	60	60	60	60	60
	PET	96	83	67	49	28	6
	CMB	-36	-23	-7	+11	+32	+54
SOUTH	PPT	60	60	60	60	60	60
	PET	96	105	110	112	110	103
	CMB	-36	-45	-50	-52	-50	-43
NE/NW	PPT	60	60	60	60	60	60
	PET	96	89	78	66	52	41
	CMB	-36	-29	-18	-6	+8	+19
SE/SW	PPT	60	60	60	60	60	60
	PET	96	104	109	111	109	104
	CMB	-36	-44	-49	-51	-49	-44
E/W	PPT	60	60	60	60	60	60
	PET	96	97	96	93	89	82
	CMB	-36	-37	-36	-33	-29	-22

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.7e

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for tne montn of September at an Elevation of 1600 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	45	45	45	45	45	45
	PET	50	36	21	4	0	0
	CMB	-5	+9	+24	+41	+45	+45
SOUTH	PPT	45	45	45	45	45	45
	PET	50	61	70	76	80	79
	CMB	-5	-16	-25	-31	-35	-34
NE/NW	PPT	45	45	45	45	45	45
	PET	50	41	32	21	12	4
	CMB	-5	+4	+13	+24	+33	+41
SE/SW	PPT	45	45	45	45	45	45
	PET	50	59	65	70	72	71
	CMB	-5	-14	-20	-25	-27	-26
E/W	PPT	45	45	45	45	45	45
	PET	50	51	50	48	45	42
	CMB	-5	-6	-5	-3	0	+3

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.8a

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of May at an Elevation of 1800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	46	46	46	46	46	46
	PET	87	78	68	55	39	22
	CMB	-41	-32	-22	-9	+7	+24
SOUTH	PPT	46	46	46	46	46	46
	PET	87	92	93	92	88	80
	CMB	-41	-46	-47	-46	-42	-34
NE/NW	PPT	46	46	46	46	46	46
	PET	87	82	74	63	52	41
	CMB	-41	-36	-28	-17	-6	+5
SE/SW	PPT	46	46	46	46	46	46
	PET	87	91	92	92	88	82
	CMB	-41	-45	-46	-46	-42	-36
E/W	PPT	46	46	46	46	46	46
	PET	87	87	85	80	75	68
	CMB	-41	-41	-39	-34	-29	-22

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.8b

Estimated Average Monthly Precipitation (PPT[1] mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of June at an Elevation of 1800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	57	57	57	57	57	57
	PET	107	100	91	79	64	46
	CMB	-50	-43	-34	-22	-7	+11
SOUTH	PPT	57	57	57	57	57	57
	PET	107	110	109	105	98	88
	CMB	-50	-53	-52	-48	-41	-31
NE/NW	PPT	57	57	57	57	57	57
	PET	107	103	96	85	73	60
	CMB	-50	-46	-39	-28	-16	-3
SE/SW	PPT	57	57	57	57	57	57
	PET	107	110	109	106	100	92
	CMB	-50	-53	-52	-49	-43	-35
E/W	PPT	57	57	57	57	57	57
	PET	107	107	104	99	92	78
	CMB	-50	-50	-47	-42	-35	-21

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.8c

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of July at an Elevation of 1800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	50	50	50	50	50	50
	PET	119	110	97	80	61	38
	CMB	-69	-60	-47	-30	-11	+12
SOUTH	PPT	50	50	50	50	50	50
	PET	119	124	125	121	114	103
	CMB	-69	-74	-75	-71	-64	-53
NE/NW	PPT	50	50	50	50	50	50
	PET	119	114	104	91	76	61
	CMB	-69	-64	-54	-41	-26	-11
SE/SW	PPT	50	50	50	50	50	50
	PET	119	123	125	123	117	108
	CMB	-69	-73	-75	-73	-67	-58
E/W	PPT	50	50	50	50	50	50
	PET	119	119	117	105	103	95
	CMB	-69	-69	-67	-55	-53	-45

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.8d

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of August at an Elevation of 1800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	66	66	66	66	66	66
	PET	92	80	65	47	26	5
	CMB	-26	-14	+1	+19	+40	+61
SOUTH	PPT	66	66	66	66	66	66
	PET	92	101	107	108	106	99
	CMB	-26	-35	-41	-42	-40	-33
NE/NW	PPT	66	66	66	66	66	66
	PET	92	86	75	63	50	38
	CMB	-26	-20	-9	+3	+16	+28
SE/SW	PPT	66	66	66	66	66	66
	PET	92	100	105	107	105	100
	CMB	-26	-34	-39	-41	-39	-34
E/W	PPT	66	66	66	66	66	66
	PET	92	94	93	90	86	78
	CMB	-26	-28	-27	-24	-20	-12

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

TABLE A.8e

Estimated Average Monthly Precipitation (PPT[1]mm), Potential Evapotranspiration (PET mm) and Climatic Moisture Balance (CMB[2] mm) Totals as a Function of Site Aspect and Inclination from the Horizontal for the month of September at an Elevation of 1800 metres.

		SITE INCLINATION FROM HORIZONTAL					
ASPECT		0°	10°	20°	30°	40°	50°
NORTH	PPT	49	49	49	49	49	49
	PET	48	35	20	4	0	0
	CMB	+1	+14	+29	+45	+49	+49
SOUTH	PPT	49	49	49	49	49	49
	PET	48	59	67	73	76	76
	CMB	+1	-10	-18	-24	-27	-27
NE/NW	PPT	49	49	49	49	49	49
	PET	48	40	30	20	11	4
	CMB	+1	+9	+19	+29	+38	+45
SE/SW	PPT	49	49	49	49	49	49
	PET	48	56	63	67	69	67
	CMB	+1	-7	-14	-18	-20	-18
E/W	PPT	49	49	49	49	49	49
	PET	48	49	48	47	43	40
	CMB	+1	0	+1	+2	+6	+9

1 Estimated monthly PPT have been interpolated from limited data.

2 A climatic moisture deficit is denoted as a -CMB and a climatic moisture surplus as a +CMB.

APPENDIX B
SOIL CORRELATION

Soil Correlation		Ecosystem Correlation	Vegetation Correl'n	
This Study	Young & Fenger (In progress)	Mitchell et al (1981)	Lea (in prep.)	
			Zone	Vegetation Landscape
Soil Type	Soil Association	Ecosystem Association		
M1	Tranquille (TQ)	PPBGal-I	IBG	WS
M2	Trapp Lake (TP) McQueen (MQ)	PPBGal-I PPBGdOa-I	IBG	WS
M3	Aylmar (AY) Mossey (MS)	IDFaOa	IDa	PF
M4	Timber (TM)	PPBGd-IVa PPBGd-IIIc	IDa	PS PW, PF
M5	Tunkwa (TW)	IDFbl-IVa IDFa-VIa(IVa)	IDb	LP, AP BA, DC
M6	Beaverhut (BT) Alkali (AK)	MSc-IVa(IIe) ESSFd-IIa	SAeS-alF	LG LL
CO	-	-	IBG	-
C1	Courteney (CT)	PPBGal-I	IBG	RW SC
C2	Commonage (CO)	PPBGal-I	IBG	RW SC
C3	-	IDFaOa-Ib	IDa	PF
C4	Cavanaugh (CG)	PPBGd-IIa PPBGd-IIIb(IIId)	IDa	PW, PF PR, DS
C5	Chasm (CM)	IDFa-Vb IDFbl-Ie	IDb	DW DM
C6	Helmcken (HN) Placid (PD)	MSc-Ib ESSFd-Ia(Id)	SAeS-alF	LD

F0	Frances (FS)	-----	IBG	CD
F1	Godey (GD)	PPBGal-I	IBG	NS
F2	Glimpse(GS)	PPBGal-I	IBG	NS
F3	Gwenn (GW)	IDFaOa	IDa	PF
F4	Glossey (GY)	PPBGd-IIa PPBGd-IIIa	IDa	PS PC
F5	Gisborne (GN)	IDFa-VIIa IDFb1-Vb	IDb	LS AS
L0	-----		IBG	SP
L1	Lundbom (LM)	PPBGal-I	IBG	SS
L2	Laluwissen (LS)	PPBGal-I	IBG	SS
L3	-----	IDFaOa	IDa	CF
0	Rayonier (RA)	-----	----	SB SF CM

Also, soil type F1x correlates with vegetation landscapes BM and PJ; F2x with BM; F4x with DJ and CS; and F5x with CS.

APPENDIX C
VEGETATION

C.1 PLANT SPECIES LIST

The following is a list of plant species that are mentioned in this report and on maps associated with this project. Common and botanical names of vascular plants follow Taylor and MacBryde (1977). Botanical names of mosses follow Crum et al. (1973) and of lichens follow Hale and Culberson (1970).

Common Name	Botanical Name
alders	*Alnus spp.*
alfalfa	*Medicago sativa*
alpine fir	*Abies lasiocarpa*
American red raspberry	*Rubus idaeus*
American vetch	*Vicia americana*
arboreal alectoria lichens	*Alectoria spp.*
arctic lupine	*Lupinus arcticus*
arrow-leaved balsamroot	*Balsamorhiza sagittata*
big sagebrush	*Artemisia tridentata subsp. tridentata*
birch-leaved spirea	*Spiraea betulifolia*
black blueberry	*Vaccinium membranaceum*
black cottonwood	*Populus balsamifera subsp. trichocarpa*
black swamp gooseberry	*Ribes lacustre*
blue grass	*Poa spp.*
bluejoint small reed grass	*Calamagrostis canadensis*
blueberries	*Vaccinium spp.*
bluebunch wheat grass	*Agropyron spicatum*
brittle prickly-pear cactus	*Opuntia fragilis*

Common Name	Botanical Name
Canadian bunchberry	*Cornus canadensis*
choke cherry	*Prunus virginiana*
clovers	*Trifolium spp.*
common cattail	*Typha latifolia*
common dandelion	*Taraxacum officinale*
common horsetail	*Equisetum arvense*
common juniper	*Juniperus communis*
common moss	*Pleurozium schreberi*
common rabbitbrush	*Chrysothamnus nauseosus*
common saskatoon	*Amelanchier alnifolia*
common selaginella	*Selaginella densa*
common snowberry	*Symphoricarpos albus*
common timothy	*Phleum pratense*
cream-coloured peavine	*Lathyrus ochroleucus*
crested wheat grass	*Agropyron cristatum*
currants	*Ribes spp.*
dandelion	*Taraxacum officinale*
diffuse knapweed	*Centaurea diffusa*
Douglas-fir	*Pseudotsuga menziesii*
drooping brome grass	*Bromus tectorum*
dwarf blueberry	*Vaccinium caespitosum*
elders	*Sambucus spp.*
Engelmann spruce	*Picea engelmannii*
feather moss	*Ptilium crista-castrensis*
fireweed	*Epilobium angustifolium*
foxtail barley	*Hordeum jubatum*

Common Name	Botanical Name
glandular birch	*Betula glandulosa*
great mullein	*Verbascum thapsus*
grouseberry	*Vaccinium scoparium*
hawkweeds	*Hieracium spp.*
heart-leaved arnica	*Arnica cordifolia*
high bush cranberry	*Viburnum edule*
horsetails	*Equisetum spp.*
Kentucky blue grass	*Poa pratensis*
kinnikinnick	*Arctostaphylos uva-ursi*
knapweed	*Centaurea spp.*
lance-leaved stonecrop	*Sedum lanceolatum*
layered moss	*Hylocomium splendens*
lodgepole pine	*Pinus contorta*
low pussytoes	*Antennaria dimorpha*
lupines	*Lupinus spp.*
needle-and-thread grass	*Stipa comata*
needle grasses	*Stipa spp.*
northern twinflower	*Linnaea borealis*
northwestern sedge	*Carex concinnoides*
Oregon boxwood	*Paxistima myrsinites*
Oregon-grape	*Mahonia spp. (mainly M. repens)*
Pacific field wormwood	*Artemisia campestris*
Pacific menziesia	*Menziesia ferruginea*
paper birch	*Betula papyrifera*

Common Name	Botanical Name
penstemons	*Penstemon spp.*
pine grass	*Calamagrostis rubescens*
poison-ivy	*Toxicodendron rydbergii*
ponderosa pine	*Pinus ponderosa*
prairie koeleria	*Koeleria macrantha*
prairie sagebrush	*Artemisia frigida*
prickly-pear cactus	*Opuntia spp. (O. fragilis and O. polyacantha)*
Pursh's sea-blite	*Suaeda depressa*
pussytoes	*Antennania spp.*
racemose pussytoes	*Antennaria racemosa*
red goosefoot	*Chenopodium rubrum*
red-osier dogwood	*Cornus sericea*
redstem ceanothus	*Ceanothus sanguineus*
Rocky Mountain Douglas-fir	*Pseudotsuga menziesii var. glauca*
Rocky Mountain juniper	*Juniperus scopulorum*
Rocky Mountain maple	*Acer glabrum*
roses	*Rosa spp. (mainly R. acicularis)*
rough fescue	*Festuca scabrella*
round-leaved alumroot	*Heuchera cylindrica*
sagebrush mariposa lily	*Calochortus macrocarpus*
sand dropseed	*Sporobolus cryptandrus*
Sandberg's blue grass	*Poa sandbergii*
Scouler's willow	*Salix scouleriana*
sedges	*Carex spp.*
shaggy fleabane	*Erigeron pumilus*
showy aster	*Aster conspicuus*
shrubby penstemon	*Penstemon fruticosus*

Common Name	Botanical Name
Sitka alder	*Alnus viridis subsp. sinuata*
smooth sumac	*Rhus glabra*
snowbush ceanothus	*Ceanothus velutinus*
soopolallie	*Shepherdia canadensis*
spotted knapweed	*Centaurea maculosa*
spreading dogbane	*Apocynum androsaemifolium*
spruce	*Picea glauca X engelmannii*
thin-leaved mountain alder	*Alnus incana subsp. tenuifolia*
thistles	*Cirsium spp.*
timber milk-vetch	*Astragalus miser*
trembling aspen	*Populus tremuloides*
umbrellaplant	*Eriogonum spp.*
western birch	*Betula occidentalis*
western needle grass	*Stipa occidentalis*
western thimbleberry	*Rubus parviflorus*
white spruce	*Picea glauca*
white-flowered rhododendron	*Rhododendron albiflorum*
wild rye grasses	*Elymus spp.*
wild sarsaparilla	*Aralia nudicaulis*
wild strawberry	*Fragaria virginiana*
willows	*Salix spp.*
wood-rushes	*Luzula spp.*
yarrow	*Achillea millefolium*

C.2 CORRELATION OF PRESENT VEGETATION STUDY TO PREVIOUS STUDIES

Previous studies have described vegetation similar to that of the present study area. These include Spilsbury and Tisdale (1944) for the Kamloops area (including part of the present study area), Tisdale (1947) for southern British Columbia, Daubenmire (1952) for northern Idaho and Washington, Tisdale and McLean (1957) for southern British Columbia, Brayshaw (1965) for southern British Columbia, van Ryswyk et al. (1966) for southern British Columbia, McLean (1970) for the Similkameen Valley, Krajina (1970) for all of British Columbia, Franklin and Dyrness (1973) for Oregon and Washington, Pfister et al. (1977) for Montana, Mueggler and Stewart (1980) for western Montana, and Mitchell et al. (1981) for south-central British Columbia and Steele et al. (1981) for Central Idaho.

C.2.1 VEGETATION ZONATION

Vegetation Zonation for the present study is described in Chapter 4. Vegetation Zonation has been described by many of the above authors. Mitchell and others (1981) have mapped biogeoclimatic zonation for the study area at a scale of 1:125 000. Comparison of these units to the present study are shown in Table C.1. Similarities and differences of the two classifications are discussed by Vegetation Zone and Subzone, along with other studies that deal with similar vegetation.

Interior Bunch Grass Zone

Similar vegetation is described by many other studies. Mitchell and others (1981) recognize this area as the Very Dry Northern Ponderosa Pine - Bunch Grass Subzone, Grassland Variant of the Ponderosa Pine - Bunch Grass Biogeoclimatic Zone with a zonal ecosystem association dominated by bluebunch wheat grass, big sagebrush and prairie koeleria. Spilsbury and Tisdale (1944), Tisdale (1947) and van Ryswyk et al. (1966) recognize the existence of three grassland belts which are present to the east of the study area. Only the

TABLE C.1 COMPARISON OF VEGETATION ZONATION FOR THE PRESENT STUDY BIOGEOCLIMATIC ZONATION.

Present Study		Biogeoclimatic (Mitchell and others, 1981)	
Vegetation Zone [1]	Subzone	Zone	Subzone
Interior bunch grass zone (IBG)		Ponderosa pine - bunchgrass (PPBG)	Very Dry Northern PPBG, Grassland (PPBGa)
Interior Rocky Mountain Douglas-fir (ID)	Ponderosa pine subzone (IDa)		Very Dry Northern PPBG, Forested (PPBGd)
		Interior Douglas-fir (IDF)	Very Dry Submontane IDG (IDFa)
	Lodgepole pine subzone (IDb)		Very Dry Montane IDF (IDFb)
Sublapine Engelmann spruce - alpine fir zone (SAeS-alF)	Rocky Mountain Douglas-fir-lodgepole pine subzone (SAes-alFa)	Montane Spruce (MS)	Very Dry Southern MS (MSc)

[1] Vegetation Zones and Subzones are described in Chapter 4.

Subalpine Engelmann Spruce - Alpine Fir Zone

The existence of this zone directly above a Rocky Mountain Douglas-fir climax zone is recognized by Krajina (1970) and Daubenmire (1952), while Pfister et al. (1977), Franklin and Dyrness (1973) and McLean (1970) recognize a similar zone with alpine fir the dominant climax species, and Engelmann spruce occurring as a seral species. Mitchell et al. (1981) divide this area into two distinct biogeoclimatic zones, a Montane spruce zone and an Engelmann spruce - subalpine fir zone although it is recognized that in both zones Engelmann spruce and alpine fir may be climax species on mesic sites. Within the study area, the status of climax stands is difficult to determine because of the predominance of seral stands.

Rocky Mountain Douglas-fir - Lodgepole Pine Subzone

Daubenmire (1952), Pfister (1977), McLean (1970) and Franklin and Dyrness (1973) recognize that an area exists within the Subalpine Engelmann spruce - alpine fir zone where Rocky Mountain Douglas-fir is seral. This occurs at the lower elevations of the zone. Within the study area Mitchell et al. (1981) recognize a very dry Southern Montane spruce subzone that approximates the area of the Rocky Mountain Douglas-fir - lodgepole pine subzone of the present study.

C.2.2 VEGETATION LANDSCAPES

Vegetation Landscapes are described in Chapter 4. Their climax communities are a fairly broad level of classification approximating plant associations described by various authors who have studied similar vegetation. Table C.2 allows comparison of climax communities of Vegetation Landscapes to plant associations of habitat types while Table C.3 allows comparison of climax communities of Vegetation Landcapes to plant associations of biogeocoenoses.

Lower Grassland described in these three studies which has a bluebunch wheat grass - big sagebrush climax, occurs in the study area. However, the Upper Grassland of these studies which has a climax of bluebunch wheat grass and rough fescue is quite similar to early successional stages of the Ponderosa pine - rough fescue vegetation landscape (PF) of the present study and this is included in the Ponderosa pine subzone of the Interior Rocky Mountain Douglas-fir zone of this study. Other studies that describe areas of bluebunch wheat grass climax zones include McLean (1970), Mueggler and Stewart (1980) and Franklin and Dyrness (1973).

Interior Rocky Mountain Douglas-fir Zone

Ponderosa pine subzone

Similar vegetation is described by many other studies. However, in some other studies this vegetation is recognized as two distinct zones, one with ponderosa pine climax and one with ponderosa pine seral to climax Rocky Mountain Douglas-fir including Mitchell et al. (1981), Franklin and Dyrness (1973), McLean (1970), Pfister et al. (1977), Brayshaw (1965), Krajina (1970) and Daubenmire (1952). Brayshaw (1965) and Franklin and Dyrness (1973) recognize that in certain locations there is no area of climax ponderosa pine forests between the grassland zone and the Interior Rocky Mountain Douglas-fir zone. This pattern is recognized in the present study. Most of the above authors recognize an area where ponderosa pine is seral to Rocky Mountain Douglas-fir.

Lodgepole Pine Subzone

This area, where lodgepole pine is seral to Rocky Mountain Douglas-fir, is also recognized by McLean (1970), Franklin and Dyrness (1973), Mitchell et al. (1981), Daubenmire (1952) and Pfister et al. (1977).

TABLE C.2 COMPARISON OF CLIMAX COMMUNITIES OF LANDSCAPES[1] TO PLANT ASSOCIATIONS OF HABITAT TYPES AND OTHER STUDIES.

Plant Associations of Habitat Types (h.t.)	Source	Also Described By	Corresonding Vegetation Types of Vegetation Landscapes
Artemisia tridentata/ Agropyron spicatum h. t. (big sagebrush/bluebunch wheat grass h.t.)	Mueggler and Stewart (1980); McLean (1970)	Tisdale (1947); Spilsbury and Tisdale (1944); Franklin and Dyrness (1973)	Bluebunch wheat grass - big sagebrush (WS); Needle-and-thread grass - big sagebrush (NS); Big sagebrush - prairie sagebrush (SS)
Pseudotsyga menziesii/ Agropyron spicatum h.t. (Rocky Mountain Douglas-fir/bluebunch wheat grass h.t.)	Pfister et al. (1977); McLean (1970); Steele et al. (1981)		Ponderosa pine - big sagebrush (PS)
Pseudotsuga mensiesii/ Calamagrostis rubescens h.t. (Rocky Mountain Douglas-fir/pine grass h.t.)	Pfister et al. (1977); McLean (1970); Daubenmire (1952); Steele et al. (1981)	Brayshaw (1965); Tisdale and McLean (1957)	Lodgepole pine - pine grass (LP); Rocky Mountain Douglas-fir - redstem ceanothus (DC); Trembling aspen - pine grass (AP); Ponderosa pine - snowbush ceanothus (PC); Ponderosa pine - bluebunch wheat grass (PM); Douglas-fir - bluebunch wheat grass (DW)
Picea/Vaccinium caespitosum h.t. (spruce/dwarf blueberry h.t.)	Pfister et al. (1977)		Lodgepole pine - spruce (LS)
Abies lasiocarpa/Vaccinium caespitosum h.t. (alpine fir/dwarf blueberry h.t.); Abies lasiocarpa/Vaccinium scoparium h.t. (alpine fir/grouseberry h.t. (pine grass phase)	Pfister et al. (1977); McLean (1970); Steele et al. (1981)		Lodgepole pine - grouseberry (LG)

[1] For descriptions of Vegetation Landscapes see Chapter 4.

TABLE C.3 COMPARISON OF CLIMAX COMMUNITIES OF VEGETATION LANDSCAPES[1] TO PLANT ASSOCIATIONS OF BIOGEOCOENOSES.

Plant Associations of Biogeoceoenoses	Source	Corresponding Vegetation Types of Vegetation Landscapes
Artemisia tridentata - Agropyron spictum association (big sagebrush - bluebunch wheat grass association)	Mitchell et al. (1981); Krajina (1970)	Bluebunch wheat grass - big sagebrush (WS) Needle-and-thread grass - big sagebrush (NS) Big sagebrush - prairie sagebrush (SS)
Pseudotsuga menziesii/Symphoricarpos albus - Calamagrostis rubescens association (Rocky Mountain Douglas-fir/common snowberry - pine grass association)	Mitchell et al. (1981); Krajina (1970)	Ponderosa pine - bluebunch wheat grass (PW)
Picea (Pseudotsuga menziesii)/Cornus sericea association (Hybrid spruce (Douglas-fir)/red-osier dogwood association)	Mitchell et al. (1981)	Black cottonwood - white spruce (CS)
Pseudotsuga menziesii (Pinus contorta)/ Linnaea borealis-Calamagrostis rubescens association (Rocky Mountain Douglas-fir (lodgepole pine)/northern twinflower - pine grass association)	Mitchell et al. (1981); Krajina (1970)	Lodgepole pine - pine grass (LP) Rocky Mountain Douglas-fir - redstem ceanothus (DC) Trembling aspen - pine grass (AP)
Picea engelmannii (Pinus contorta)/ Vaccinium scoparium - Arnica cordifolia association (Engelmann spruce (lodgepole pine)/ grouseberry - heart-leaved arnica association)	Mitchell et al. (1981); Krajina (1970)	Lodgepole pine - grouseberry (LG) Lodgepole pine - arctic lupine (LL) Lodgepole pine - Rocky Mountain Douglas-fir (LD)

[1] For description of Vegetation Landscapes see Chapter 4